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FATIGUE, TENSILE AND CREEP PROPERTIES OF 17-7 PH TH 1050 AND AM 350 SCT SHEET

COLIN D. BASS, 1/LT, USAF

C. L. HARMSWORTH

TECHNICAL REPORT AFML-TR-69-331

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AFML-TR-69-331

FATIGUE, TENSILE AND CREEP PROPERTIES OF 17-7 PH TH 1050 AND AM 350 SCT SHEET

COLIN D. BASS, 1/LT, USAF

C. L. HARMSWORTH

FOREWORD

This report was prepared by Lt. Colin D. Bass and C. L. Harmsworth of the Materials Engineering Branch, Materials Support Division, Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio. This program was conducted under Project No. 7381, "Materials Applications," Task No. 738106, "Engineering and Design Data Development." This report covers work conducted from November 1966 through September 1969. The manuscript was released by the authors in December 1969 for publication as a Technical Report.

The testing was done by Materials Engineering Branch, Materials Support Division, Air Force Materials Laboratory. Much of the fatigue testing was conducted by Dale S. Opela and the creep testing and data reduction were accomplished by Richard J. Marton of the University of Dayton Research Institute.

All (or many) of the items compared in this report were commercial items that were not developed or manufactured to meet any Government specifications, to withstand the tests to which they were subjected, or to operate as applied during this study. Any failure to meet the objectives of this study is no reflection on any of the commercial items discussed herein or on any manufacturer.

This technical report has been reviewed and is approved.

Albert Olevitch

ALBERT OLEVITCH
Chief, Materials Engineering Branch
Materials Support Division
Air Force Materials Laboratory

ABSTRACT

A test program was conducted to develop fatigue data on 17-7 PH TH 1050 and AM 350 SCT stainless steels at room and elevated temperatures. Limited stress-rupture and tensile data were also obtained. This program is part of an overall effort to obtain fatigue data for alloys which are currently in MIL-HDBK-5, but for which fatigue data is currently lacking. All data were generated to be compatible with the MIL-HDBK-5 format and are presented in tabular form as well as stress rupture curves, S-N curves, and constant life diagrams. The results indicated the 17-7 PH TH 1050 had slightly higher fatigue properties at room and elevated temperatures while the AM 350 SCT had slightly higher ultimate tensile strength. Both alloys had lower UTS and fatigue properties than 17-7 PH RH 950 and PH 15-5 MO RH 950 sheet which were tested under a companion program; however, the ductility of these other two alloys was less.

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SECTION I

INTRODUCTION

The reaction of materials to cyclic load is of primary concern in material selections for aircraft. In order to characterize fully the reactions of new materials, many fatigue tests must be run and the data must be organized in a form useful to the designer. As a step towards the accomplishment of this goal the Air Force Materials Laboratory conducted a coordinated effort with the MIL-HDBK-5 Committee to review MIL-HDBK-5 to identify those materials which were currently in MIL-HDBK-5 and for which fatigue data was either nonexistent or lacking. A joint contractual/inhouse effort was then initiated to obtain much of this data. The data obtained by the contractor (Standard Pressed Steel) on 17-7PH (RH950), PH15-7 (TH1050), and PH15-7 (RH950) have been presented in AFML-TR-69-175[1]. The results of the AFML inhouse effort on AM350 (SCT) and 17-7PH (TH1050) are contained in this report.

SECTION II

MATERIAL, PROCESSING AND SPECIMEN FABRICATION

All specimens tested in this program were provided by the Standard Pressed Steel Company to eliminate variances in processing as a possible source of error in comparing results between materials tested under the two programs. Specimens were machined to the configurations shown in Figure 1. Following is the processing and specimen fabrication as outlined by Standard Pressed Steel.

For AM350 Alloy

A. Chemical Composition

Carbon	.072	Silicon	.35
Manganese	.69	Chromium	16.63
Phosphorus	.020	Nickel	4.18
Sulphur	.017	Molybdenum	2.78
		Nitrogen	.098

B. Processing History

This material was annealed by Allegheny Ludlum Steel Corp., their batch No. 65549, at 1875°F (90 minutes per inch). This material was received by Standard Pressed Steel Company in the No. 2D Finish, Condition A to AMS5548.

C. Heat Treatment

1. Annealed at 1710°F ± 25°F, air cooled to room temperature.
2. Subzero cooled to at -100°F for 3 hours.
3. Tempered at 850°F for 3 hours.

D. Method of Manufacture

1. The sheet was sheared into specimen blanks 1/32 inch oversize.
2. Blanks were copper plated .008-.001 thick.
3. The plated blanks were annealed.
4. The annealed blanks were clamped in fixtures to eliminate distortion and were subzero cooled.
5. The blanks and fixture were all tempered.
6. The blanks were removed from the fixtures and the plating was stripped.

7. The blanks were then milled on four sides to square up edges and remove sheared surfaces.

8. Center pin holes were drilled.

9. Shank and radius was milled so that direction of rotation of the milling cutter was coincident with the axis of the specimen.

10. The notches were ground with a formed wheel.

11. Shank and milled surfaces were polished with 600 grit silicon carbide paper.

12. Immediately after polishing the parts were oiled and wrapped.

<u>For 17-7PH Steel Alloy</u>

A. Chemical Composition

Carbon	.06
Manganese	.82
Phosphorus	.026
Sulphur	.004
Silicon	.41
Chromium	17.30
Nickel	7.10
Aluminum	1.10

B. Processing History

This material was received from Edgecomb Steel Co., batch No. 3560541. The material was cold rolled, solution treated at 1950°F $\pm$ 25° and descaled. The sheet had a 2D finish and was purchased to AMS5528A.

C. Heat Treatment

Since this material was in the annealed condition it was only destabilized and aged.

1. Destabilized by holding at 1400°F for 90 minutes, air cooled to 55°F and held for 30 minutes.
2. Precipitation hardening was done by heating to 1050°F, holding for 90 minutes and air cooling to room temperature.

D. Method of Manufacture

1. The sheet was sheared into blanks, 1/32 inch oversize.
2. The blanks were destabilized and precipitation hardened.
3. The blanks were then sand blasted to remove scale.
4. All four sides were milled to removed sheared surfaces and square up edges.
5. Center pin holes were drilled.
6. Shank and radius was milled to that direction of rotation of the milling cutter was coincident with the axis of the specimens.
7. The notches were ground with a formed wheel.
8. Shank and milled surfaces were polished with 600 grit silicon carbide paper.
9. Immediately after polishing, the parts were oiled and wrapped.

SECTION III

TEST EQUIPMENT & PROCEDURES

Tensile tests were run on smooth and notched (K_t=3.0), longitudinal and transverse specimens at toom temperature, 500°F (600°F for 17-7PH), and 800°F.

Tests were run on a 50,000 pound Wiedemann tensile machine using a head speed of 0.05 inches per minute. Strain was measured at room temperature by a class B-1 microformer. At elevated temperatures an arcweld LVDT was used. Strain indicators were calibrated daily and the Wiedemann tensile machine was calibrated to 1% of full scale at six-month intervals. The elevated temperature tests were conducted using a Marshell 3-zone clam shell furnace which was controlled by a Research Incorporated 3-zone controller. Loads were applied after a 30-minute soak at test temperature. Temperature variation over the gage section did not exceed $\pm$ 3°F.

Creep-rupture tests were run on a limited number of smooth test specimens to establish complete Constant Life Diagrams. A similar number of stress-rupture tests were run on notched specimens. All rupture tests were conducted in Arcweld creep frames using arcweld furnaces and L&N controller-recorders. Arcweld LVDT's were used to measure creep. Elongation data was obtained periodically on an automatic data logger system.

Fatigue tests were run per the test plan in Table 1. Two machines were used. One was a 2-ton Amsler Vibraphore which operated at frequencies up to 6000 cpm. The second machine was a vertical 2-ton Schenck machine which operated at frequencies up to 3500 cpm. Temperature variation over the gage section did not exceed $\pm$ 3°F; the same heating equipment described above for the tensile tests was used. Both fatigue machines were calibrated to 1% of full scale at six month intervals.

SECTION IV

RESULTS AND DISCUSSION

Tensile properties of both materials tested are tabulated in Tables II and III. Figures 2 and 3 show average strength values as a function of temperature. Both materials suffered about 25% loss in yield strength between room temperature and 800°F. While the 17-7PH alloy showed a similar 25% loss in ultimate strength in going to 800°F; the AM350 showed only about 10% loss in ultimate strength. Both alloys displayed lowest elongations at 500-600°F. Figure 4 shows notch/unnotched strength ratios (NSR) as a function of temperature for both longitudinal and transverse specimens. The 17-7PH NSR values for all conditions were consistently higher than those for AM350. These curves were plotted using three data points at most temperatures for each NSR value. The scatter in data for each condition was low as can be seen from Tables II and III. Consequently, variances in behavior between the transverse and longitudinal specimens of each alloy, while unexplained, are considered real.

The fatigue data for 17-7 TH1050 sheet is tabulated in Table IV. These data are also plotted as S/N curves at the appropriate test temperatures and stress ratios in Figures 5 through 14. Except for smooth material tested at "A"=0.98, the longest fatigue life was observed at 600°F, next was 800°F and shortest life was seen at room temperature. For "A"=0.98, fatigue life increased as temperature decreased. These results are not unusual in these temperature ranges for this type of material. This behavior has been noted for other stainless steels and superalloys (References 1 and 2). Obviously, at very high temperatures, above those tested, the apparent fatigue life would be decreased; however, the mechanism of failure would be primarily one of creep rather than fatigue. The only really unexpected result of these tests is the merging or crossover of the unnotched A=0.5 and A=0.98 S/N curves at room temperature as shown in Figure 12. This could be a result of the scatter from the limited number of tests rather than a real material behavior characteristic.

Table V and Figures 15 through 18 show the fatigue data generated for AM350. These data show only slight difference in fatigue life with temperature within the temperature range tested. Figures 19 through 22 compare the effect of "A" ratio on fatigue life. As expected, a stress ratio of A=0.5 resulted in longer fatigue lives than a stress ratio of A=0.89 at the same maximum stress.

Constant life diagrams for 17-7PH are shown as Figures 23 through 25 and for AM350 as Figures 26 through 28. These curves give the combination of stresses that result in a given life, either in terms of maximum and minimum stress, or in terms of alternating and mean stress. The radial lines emanating from the zero point of the horizontal axis represent various stress ratios. Both the "R" ratios (minimum stress/maximum stress) and the corresponding "A" ratios (alternating stress/mean stress) are given at the top of the figures. The point of the A=0 curve for room temperature was taken from stress rupture tests run at that temperature where such test data was available. These curves have a normal appearance.

Tables VI through IX give creep data for the smooth creep specimens. Tables X and XI give the stress rupture data for the notched specimens. Creep time-deformation curves for 17-7PH are plotted in Figures 29 and 30 and show typical creep behavior.

Figures 30 and 31 show time to a given % of creep deformation as a function of stress. Figures 32 and 33 present creep vs. time data for AM350. Generally, the AM350 exhibited no significant creep before failure. Figure 34 presents time to rupture for notched 17-7PH specimens. Figure 35 presents notched rupture data for AM350. Again, the curves are rather flat at the temperature tested. In most cases, the specimens either failed on loading or continued out past the 1000-hour mark.

CONCLUSIONS

This testing program was conducted to obtain fatigue data on alloys for which tensile data are currently in MIL-HDBK-5 but for which fatigue data are lacking. The data are presented in the form of S/N diagrams, constant life diagrams, and creep-rupture curves. The curves were fitted to the data points by eye and exhibited scatter typical of similar materials under these conditions.

The maximum useful temperature of AM350 is listed as 850°F in the Aerospace Structural Metals Handbook (Reference 3) while the maximum useful temperature of 17-7PH is listed as 800°F. This relatively minor difference in temperature capability seems to be borne out in the test program which showed only slightly higher fatigue properties at the elevated temperature for AM350, at least for the notched condition. Due to the relatively small differences and the scatter in the data, any selection between the two alloys for a given application should also consider cost, fabricability and other criteria which were not evaluated as part of this test program.

A more meaningful evaluation is made on comparing the properties of all alloys evaluated under this effort and the companion program at Standard Pressed Steel (1). Figures 37 and 38 show some of the results of this comparison. PH15-7 RH950 has the highest tensile properties as shown, at room and at elevated temperatures. This behavior is further indicated in the Aerospace Structural Metals Handbook which indicates a maximum useable temperature of 1000°F for this alloy. However, on comparing the elevated temperature fatigue properties between this and the AM350 SCT sheet at A=0.5, one finds little difference. As a matter of fact, there is little difference in the notched fatigue properties among all the alloys evaluated.

TABLE I

TEST PLAN

Test Type	Direction and Stress Ratio	Specimen Condition	17-7PH TH1050			AM350 SCT		
			Room	600°F	800°F	Room	500°F	800°F
Tensile	Transverse	Notched (K_t=3.0)	3	3	3	3	3	3
		Smooth (K_t=1.0)	3	3	3	3	3	3
	Longitudinal	Notched (K_t=3.0)	3	3	3	3	3	3
		Smooth (K_t=1.0)	3	3	3	3	3	3
Creep Rupture	Transverse	Notched (K_t=3.0)	-	5	5	-	5	5
		Smooth (K_t=1.0)	-	5	5	5	5	5
Fatigue	Transverse A=0.5	Notched (K_t=3.0)	10	10	10	10	10	10
		Smooth (K_t=1.0)	10	10	10	-	10	10
	Transverse A=0.98	Notched (K_t=3.0)	10	10	10	-	-	10
		Smooth (K_t=1.0)	10	10	10	-	-	10

TABLE II

TENSILE PROPERTIES OF 17-7PH TH1050 SHEET

Specimen No.	Direction	K_t	Test Temp. (°F)	Ultimate Strength (KSI)	Yield Strength (KSI)	Elongation (%)
TC-1	Trans.	1.0	Room	191.2	172.7	7.3
TC-2	Trans.	1.0	Room	191.2	172.7	9.0
TC-3	Trans.	1.0	Room	191.2	172.7	8.5
AVE.	Trans	1.0	Room	191.2	172.7	8.3
QB-18	Long.	1.0	Room	190.3	173.7	13.2
QB-19	Long.	1.0	Room	189.6	177.7	8.4
AVE.	Long	1.0	Room	189.9	175.7	10.8
UB-1	Trans.	3.0	Room	218.2		
UB-4	Trans.	3.0	Room	219.7		
SB-8	Trans.	3.0	Room	210.4		
AVE.	Trans.	3.0	Room	219.1		
QB-1	Long.	3.0	Room	216.4		
QB-2	Long.	3.0	Room	215.9		
QB-3	Long.	3.0	Room	215.5		
AVE.	Long.	3.0	Room	215.9		
TC-4	Trans.	1.0	600	161.0	154.8	3.4
TC-5	Trans.	1.0	600	161.3	149.6	6.1
TC-6	Trans.	1.0	600	156.5	150.0	8.2
AVE.	Trans.	1.0	600	159.6	151.5	5.9
QB-13	Long.	1.0	600	168.3	152.2	6.4
QB-14	Long.	1.0	600	165.2	155.6	6.5
QB-23	Long.	1.0	600	164.7	145.9	6.5
AVE.	Long.	1.0	600	166.1	151.2	6.5
SB-1	Trans.	3.0	600	185.2		
SB-9	Trans.	3.0	600	180.6		
SB-10	Trans.	3.0	600	180.9		
SB-47	Trans.	3.0	600	185.6		
AVE.	Trans.	3.0	600	183.1		
QB-4	Long.	3.0	600	185.9		
QB-5	Long.	3.0	600	166.7		
QB-6	Long.	3.0	600	186.0		
AVE.	Long.	3.0	600	186.2		

TABLE II (Cont'd)

Specimen No.	Direction	K_t	Test Temp. (°F)	Ultimate Strength (KSI)	Yield Strength (KSI)	Elongation (%)
VC-12	Trans.	1.0	800	142.7	136.5	8.5
VC-28	Trans.	1.0	800	143.0	135.8	10.0
VC-68	Trans.	1.0	800	141.9	138.4	11.0
AVE.	Trans.	1.0	800	142.2	136.9	9.8
QB-22	Long.	1.0	800	142.9	137.2	13.2
SB-11	Trans.	3.0	800	163.6		
SB-12	Trans.	3.0	800	162.1		
AVE.	Trans	3.0	800	162.9		
QB-7	Long.	3.0	800	166.4		
QB-8	Long.	3.0	800	165.0		
QB-9	Long.	3.0	800	164.9		
AVE.	Long.	3.0	800	165.4		

TABLE III

TENSILE PROPERTIES OF AM 350 SCT SHEET

Specimen No.	Direction	K_t	Test Temp. (°F)	Ultimate Strength (KSI)	Yield Strength (KSI)	Elongation
Z-22	Trans.	1.0	Room	204.7	175.4	12.2
Z-23	Trans.	1.0	Room	204.8	176.7	13.0
Z-24	Trans.	1.0	Room	203.8	174.1	13.3
AVE,	Trans.	1.0	Room	204.4	175.4	12.8
SD-1	Long.	1.0	Room	204.3	169.8	15.5
SD-2	Long.	1.0	Room	205.1	177.7	14.7
SD-3	Long	1.0	Room	205.3	176.4	15.2
AVE.	Long.	1.0	Room	204.9	174.6	15.1
UD-23	Trans.	3.0	Room	226.0		
UD-26	Trans.	3.0	Room	224.1		
VD-8	Trans.	3.0	Room	227.7		
AVE.	Trans.	3.0	Room	225.9		
B-6	Long.	3.0	Room	231.0		
C-2	Long.	3.0	Room	229.7		
C-3	Long.	3.0	Room	229.7		
AVE.	Long.	3.0	Room	230.1		
Y-5	Trans.	1.0	500	187.3	148.0	8.2
Y-6	Trans.	1.0	500	187.5	137.0	15.9
Y-7	Trans.	1.0	500	186.5	134.8	8.9
AVE.	Trans.	1.0	500	187.1	139.9	11.0
SD-4	Long.	1.0	500	189.0	138.7	10.1
SD-5	Long.	1.0	500	185.5	147.9	10.1
SD-6	Long.	1.0	500	188.4	148.0	10.0
AVE.	Long.	1.0	500	187.6	145.5	10.0
VD-10	Trans.	3.0	500	200.4		
VD-1[illegible]	Trans.	3.0	500	200.8		
AVE.	Trans.	3.0	500	200.6		
C-4	Long.	3.0	500	204.3		
C-5	Long.	3.0	500	203.3		
C-6	Long.	3.0	500	203.1		
AVE.	Long.	3.0	500	203.5		
SD-7	Trans.	1.0	800	186.4	119.8	11.7
SD-8	Trans.	1.0	800	186.4	128.8	10.8
SD-9	Trans.	1.0	800	187.4	133.1	11.5
AVE.	Trans.	1.0	800	186.7	127.2	11.4

TABLE III (Cont'd)

Specimen No.	Direction	K_t	Test Temp. (°F)	Ultimate Strength (KSI)	Yield Strength (KSI)	Elongation
Y-8	Long.	1.0	800	184.7	122.0	11.3
Y-9	Long.	1.0	800	186.4	122.6	11.0
Y-10	Long.	1.0	800	185.9	117.0	10.8
AVE.	Long.	1.0	800	185.7	120.5	11.0
VD-2	Trans.	3.0	800	192.3		
VD-19	Trans.	3.0	800	193.9		
VD-33	Trans.	3.0	800	194.1		
AVE.	Trans.	3.0	800	193.4		
C-7	Long.	3.0	800	201.5		
C-8	Long.	3.0	800	201.8		
C-10	Long.	3.0	800	202.1		
AVE.	Long.	3.0	800	201.8		

TABLE IV

FATIGUE DATA FOR 17-7PH TH1050 SHEET

Specimen No.	"A" Ratio	Test Temp. (°F)	Condition	Max. Stress (KSI)	Test Length (Cycles)	Remarks
TC-36	.5	Room	K_t=1.0	130	22,490,000	Did not fail
TC-37	"	"	"	135	14,205,000	Did not fail
TC-41	"	"	"	137	366,000	
TC-35	"	"	"	140	199,000	
TC-34	"	"	"	145	345,000	
TC-38	"	"	"	150	362,000	
TC-39	"	"	"	160	112,000	
TC-40	"	"	"	170	460,000	
TC-42	"	"	"	180	55,000	
UB-8	.5	Room	K_t=3.0	25	21,114,000	Did not fail
UB-9	"	"	"	30	4,594,000	
UB-11	"	"	"	35	1,382,000	
UB-29	"	"	"	40	5,868,000	
UB-7	"	"	"	45	300,000	
UB-30	"	"	"	50	348,000	
UB-22	"	"	"	60	1,038,000	
UB-41	"	"	"	70	57,000	
VC-69	.5	600°F	K_t=1.0	110	33,086,000	Did not fail
RC-1	"	"	"	140	57,000	
RC-2	"	"	"	140	10,077,000	Did not fail
RC-4	"	"	"	145	14,510,000	Did not fail
VC-71	"	"	"	150	8,818,000	
VC-73	"	"	"	150	1,423,000	
RC-25	"	"	"	155	1,394,000	
RC-24	"	"	"	160	81,000	
VC-72	"	"	"	165	24,000	
SB-28	.5	600°F	K_t=3.0	50	10,076,000	Did not fail
SB-31	"	"	"	55	12,352,000	Did not fail
SB-33	"	"	"	55	10,613,000	Did not fail
SB-24	"	"	"	57	10,414,000	Did not fail
SB-32	"	"	"	60	37,000	
SB-30	"	"	"	60	97,000	
SB-29	"	"	"	65	258,000	
SB-35	"	"	"	65	42,000	
SB-28	"	"	"	70	28,000	
SB-29	"	"	"	75	15,000	

TABLE IV (Cont'd)

Specimen No.	"A" Ratio	Test Temp. (°F)	Condition	Max. Stress (KSI)	Test Length (Cycles)	Remarks
RC-6	.5	800	K_t=1	110	10,217,000	Did not fail
RC-14	"	"	"	125	19,725,000	Did not fail
VC-1	"	"	"	135	603,000	
RC-23	"	"	"	140	12,012,000	Did not fail
UB-44	"	"	"	140	4,940,000	
UB-45	"	"	"	142	752,000	
UB-43	"	"	"	145	39,000	
TC-49	"	"	"	150	31,000	
UB-46	"	"	"	165	15,000	
SB-37	.5	800	K_t=3.0	50	14,447,000	Did not fail
SB-40	"	"	"	58	13,409,000	Did not fail
SB-38	"	"	"	60	58,000	
SB-42	"	"	"	60	8,142,000	
SB-43	"	"	"	65	49,000	
SB-46	"	"	"	65	10,179,000	
SB-41	"	"	"	70	32,000	
SB-45	"	"	"	75	10,000	
SB-44	"	"	"	80	12,000	
TC-20	.98	Room	K_t=1.0	120	18,285,400	
TC-11	"	"	"	125	13,491,000	
TC-16	"	"	"	127	9,024,200	
TC-14	"	"	"	130	722,800	
TC-13	"	"	"	135	134,200	
TC-10	"	"	"	150	86,200	
TC-12	"	"	"	165	47,600	
TC-10	"	"	"	185		Beyond capacity of Schenck
UB-22	.98	Room	K_t=3.0	30	13,652,300	Did not fail
UB-28	"	"	"	32.5	6,327,400	
UB-39	"	"	"	35	4,935,700	
UB-5	"	"	"	37.5	15,975,900	Did not fail
UB-6	"	"	"	40	391,600	
UB-37	"	"	"	45	340,100	
UB-26	"	"	"	50	46,900	
UB-27	"	"	"	55	38,100	
TC-24	.98	600	K_t=1.0	110	9,531,400	
TC-22	"	"	"	115	9,934,600	
TC-27	"	"	"	118	42,100	
TC-18	"	"	"	120	1,043,600	
TC-21	"	"	"	120	119,100	
TC-28	"	"	"	125	187,300	
TC-30	"	"	"	125	111,200	
TC-23	"	"	"	130	164,700	
TC-19	"	"	"	135	95,900	
TC-26	"	"	"	150	27,400	

TABLE IV (Cont'd)

Specimen No.	"A" Ratio	Test Temp. (°F)	Condition	Max. Stress (KSI)	Test Length (Cycles)	Remarks
RC-41	.98	600	K_t=3.0	25	22,193,000	Did not fail
RC-43	"	"	"	30	10,188,000	Did not fail
RC-44	"	"	"	32	9,459,000	
RC-40	"	"	"	35	23,000	"Mach. Overload"
RC-46	"	"	"	45	3,587,000	
SB-16	"	"	"	50	3,558,000	
RC-47	"	"	"	55	4,635,000	
SB-15	"	"	"	55	36,000	
SB-14	"	"	"	57	27,000	
SB-13	"	"	"	60	20,000	
RC-49	"	"	"	65	21,000	
PC-6	.98	800	K_t=1.0	90	947,000	Failed in grip
PC-7	"	"	"	100	2,682,000	
PC-8	"	"	"	107	39,000	
PC-5	"	"	"	115	32,000	
PC-4	"	"	"	130	36,000	
PC-3	"	"	"	135	41,000	
PC-2	"	"	"	140	20,000	
PC-1	"	"	"	145	12,000	
SB-19	.98	800	K_t=3.0	40	10,821,000	Did not fail
SB-20	"	"	"	42	10,502,000	
SB-24	"	"	"	42.5	8,618,000	
SB-23	"	"	"	43	70,000	
SB-18	"	"	"	45	42,000	
SB-21	"	"	"	48	88,000	
SB-25	"	"	"	50	27,000	
SB-22	"	"	"	60	16,000	
SB-25	"	"	"	70	10,000	

TABLE V

FATIGUE DATA FOR AM-350 SCT SHEET

Specimen No.	"A" Ratio	Test Temp. (°F)	Condition	Max Stress (KSI)	Test Length (Cycles)	Remarks
VD-5	.5	Room	K_t=3.0	50	14,885,000	
VD-15	"	"	"	60	20,109,000	
VD-16	"	"	"	65	15,094,000	Did not fail
VD-18	"	"	"	68	24,485,000	
VD-13	"	"	"	70	503,000	
VD-7	"	"	"	80	112,000	
VD-11	"	"	"	90	49,000	
VD-14	"	"	"	100	21,000	
VD-17	"	"	"	110	16,000	
UD-19	.5	500	K_t=1.0	130	7,585,000	
UD-25	"	"	"	147	13,550,000	
UD-21	"	"	"	150	6,849,000	
UD-30	"	"	"	150	166,000	
UD-28	"	"	"	153	117,000	
UD-27	"	"	"	155	175,000	
UD-24	"	"	"	160	102,900	
UD-31	"	"	"	160	353,000	
UD-22	"	"	"	170	63,000	
UD-29	"	"	"	180	39,000	
VD-21	.5	500	K_t=3.0	60	13,293,000	
Z-10	"	"	"	60	63,000	
VD-32	"	"	"	65	55,000	
VD-23	"	"	"	70	5,225,000	
VD-28	"	"	"	70	83,000	
VD-26	"	"	"	73	17,000	
VD-24	"	"	"	75	52,000	
VD-29	"	"	"	75	22,000	
VD-20	"	"	"	80	22,000	
VD-25	"	"	"	85	17,000	
VD-36	.5	800	K_t=1.0	140	1,975,000	
UD-37	"	"	"	140	2,309,000	
VD-38	"	"	"	145	3,717,000	
UD-34	"	"	"	150	24,000	
UD-38	"	"	"	155	1,730,000	
VD-37	"	"	"	155	35,000	
VD-31	"	"	"	163	19,000	
VD-35	"	"	"	170	21,600	

TABLE V (Cont'd)

Specimen No.	"A" Ratio	Test Temp. (°F)	Condition	Max Stress (KSI)	Test Length (Cycles)	Remarks
Z-11	.5	800	K_t=3.0	65	9,887,000	
Z-21	"	"	"	70	1,607,000	
Z-20	"	"	"	70	811,000	
Z-28	"	"	"	75	57,000	
Z-12	"	"	"	75	1,440,000	
Z-19	"	"	"	77	731,000	
Z-16	"	"	"	80	36,000	
Z-15	"	"	"	80	19,000	
Z-13	"	"	"	85	17,000	
Z-35	.98	Room	K_t=3.0	55	3,766,000	
Z-34	"	"	"	60	1,653,200	
Z-36	"	"	"	65	114,000	
Z-30	"	"	"	70	122,000	
Z-31	"	"	"	85	22,000	
Z-33	"	"	"	100	18,600	
Z-39	.98	500	K_t=3.0	45	13,574,000	
Z-42	"	"	"	50	13,924,000	
Z-48	"	"	"	52.5	3,856,300	
Z-32	"	"	"	55	86,000	
Z-41	"	"	"	60	83,000	
Z-46	"	"	"	62.5	37,000	
Z-43	"	"	"	65	37,000	
X-16	.98	800	K_t=1.0	80	16,766,000	Did not fail
Z-40	"	"	"	90	14,065,000	
X-17	"	"	"	95	6,516,000	
X-18	"	"	"	105	2,894,000	
Z-47	"	"	"	110	51,000	
UD-33	"	"	"	115	1,301,000	
Z-44	"	"	"	125	1,588,000	
UD-36	"	"	"	130	759,000	
Z-27	"	"	"	140	27,000	
VD-4	.98	800	K_t=3.0	40	12,879,000	
VD-3	"	"	"	45	4,208,800	
Y-31	"	"	"	50	3,912,000	
Y-27	"	"	"	50	1,716,000	
Y-33	"	"	"	55	146,500	
Y-30	"	"	"	55	136,000	
Y-28	"	"	"	60	155,000	
Y-32	"	"	"	60	18,300	
Y-29	"	"	"	65	49,000	
Y-34	"	"	"	65	98,000	

TABLE VI

CREEP DATA FOR 17-7PH STAINLESS STEEL, 600°F

STRESS = 150 KSI

Spec. Nr. RC-35	
Time (Hrs)	Creep %
0.01	0.00
0.02	0.02
0.05	0.02
0.10	0.03
0.20	0.03
0.50	0.05
1.00	0.06
2.00	0.08
5.00	0.11
10.00	0.14
20.00	0.18
50.00	0.30
100.00	0.46
116.00	End of Test. Did not Fracture.

STRESS = 160 KSI

Spec. Nr. RC-36		Spec. Nr. RC-37		Average RC-36 & RC-37	
Time (Hrs)	Creep %	Time (Hrs)	Creep %	Time (Hrs)	Creep %
0.01	0.00	0.01	0.00	0.01	0.00
0.02	0.03	0.02	0.01	0.02	0.02
0.05	0.05	0.05	0.03	0.05	0.04
0.10	0.07	0.10	0.04	0.10	0.06
0.20	0.10	0.20	0.06	0.20	0.08
0.50	0.12	0.50	0.10	0.50	0.11
1.00	0.17	1.00	0.14	1.00	0.16
2.00	0.25	2.00	0.19	2.00	0.22
5.00	0.36	5.00	0.30	5.00	0.33
10.00		10.00	0.45	10.00	0.45
20.00	0.73	20.00	0.71	20.00	0.72
50.00	1.67	50.00	1.28	50.00	1.48
92.00(1)		100.00	2.21	100.00	2.21
100.00	2.53	200.00	3.80	200.00	3.80
123.5 (2)		340.00	Fracture		
124.00	Fracture				

(1) Temperature rose to 650°F.
(2) Temperature rose to 735°F.

TABLE VI (Cont'd)

STRESS = 165 KSI

Spec. Nr. TC-43	
Time (Hrs)	Creep %
Fractured on Loading	

STRESS = 170 KSI

Spec. Nr. RC-34	
Time (Hrs)	Creep %
0.01	0.00
0.02	0.04
0.05	0.09
0.10	0.13
0.20	0.21
0.50	0.33
1.00	0.47
2.00	0.71
5.00	1.31
10.00	1.98
20.00	4.40
26.13	Fracture

TABLE VII

CREEP DATA FOR 17-7PH STAINLESS STEEL, 800°F

STRESS = 95 KSI

Spec. Nr. TC-48	
Time (Hrs)	Creep %
0.01	0.00
0.02	0.01
0.05	0.02
0.10	0.03
0.20	0.05
0.50	0.09
1.00	0.13
2.00	0.20
5.00	0.36
10.00	0.54
20.00	0.84
50.00	1.42
100.00	2.04
200.00	2.82
500.00	4.65
1000.00	9.06

STRESS = 105 KSI

Spec. Nr. TC-46		Spec. Nr. TC-47		Average TC-46 & TC-47	
Time (Hrs)	Creep %	Time (Hrs)	Creep %	Time (Hrs)	Creep %
0.01	0.00	0.01	0.00	0.01	0.00
0.02	0.01	0.02	0.01	0.02	0.01
0.05	0.02	0.05	0.03	0.05	0.03
0.10	0.05	0.10	0.05	0.10	0.05
0.20	0.08	0.20	0.09	0.20	0.09
0.50	0.15	0.50	0.17	0.50	0.16
1.00	0.24	1.00	0.30	1.00	0.27
2.00	0.40	2.00	0.50	2.00	0.45
5.00	0.79	5.00	1.10	5.00	0.95
7.00	Fracture	10.00	1.95	10.00	1.95
		20.00	3.66	20.00	3.66
		50.00	11.44	50.00	11.44
		53.2	Fracture		

TABLE VII (Cont'd)

STRESS = 115 KSI

Spec. Nr. TC-45	
Time (Hrs)	Creep %
0.01	0.00
0.02	0.04
0.05	0.06
0.10	0.10
0.20	0.15
0.50	0.24
1.00	0.39
2.00	0.67
5.00	1.52
10.00	2.74
19.2	Fracture

STRESS = 120 KSI

Spec Nr. TC-44	
Time (Hrs)	Creep %
0.01	0.00
0.02	0.02
0.05	0.08
0.10	0.15
0.20	0.27
0.50	0.58
1.00	1.10
2.00	2.25
5.00	6.33
6.29	Fracture

TABLE VIII

CREEP DATA FOR AM350 STAINLESS STEEL, 500°F

STRESS = 150 KSI

Spec. Nr. Z-14	
Time (Hrs)	Creep %
0.01	0.00
0.02	0.00
0.05	0.00
0.10	0.00
0.20	0.01
0.50	0.01
1.00	0.02
2.00	0.02
5.00	0.03
10.00	0.02
20.00	0.01
50.00	0.02
100.00	0.01
200.00	0.01
500.00	-0.03
1000.00	-0.01

STRESS = 180 KSI

Spec. Nr. X-36	
Time (Hrs)	Creep %
0.01	0.00
0.02	0.00
0.05	0.00
0.10	0.00
0.20	0.00
0.50	0.00
1.00	0.01
2.00	0.00
5.00	-0.01
10.00	0.00
20.00	0.00
50.00	0.00
100.00	0.03
150.00	Removed Load No Fracture

STRESS = 170 KSI

Spec. Nr. Y-44	
0.01	0.00
0.02	0.00
0.05	0.03
0.10	0.03
0.20	0.03
0.50	0.04
1.00	0.04
2.00	0.05
5.00	0.07
10.00	0.06
20.00	0.04
50.00	0.04
100.00	0.04
141.00	Removed Load - No Fracture

STRESS = 190 KSI

Spec. Nr. Z-5
Failed on Loading

STRESS = 200 KSI

Spec. Nr. Z-1
Failed on Loading

TABLE IX

CREEP DATA FOR AM350 STAINLESS STEEL, 800°F

STRESS = 180 KSI

Spec. Nr. Z-9	
Time (Hrs)	Creep %
0.01	0.00
0.02	0.06
0.05	0.13
0.10	0.14
0.20	0.03
0.50	0.06
1.00	0.08
2.00	0.11
5.00	0.14
10.00	0.17
20.00	0.27
50.00	0.51
100.00	0.60
200.00	--
500.00	1.25
724.5	Fractured

STRESS = 182 KSI

Spec. Nr. Z-26	
Time (Hrs)	Creep %
0.01	0.00
0.02	0.00
0.05	0.00
0.10	0.00
0.20	0.00
0.50	0.00
1.00	0.00
2.00	0.00
5.00	0.02
10.00	0.08
20.00	0.12
50.00	0.00
100.00	0.01
200.00	0.03
205.50	Fractured

STRESS = 184 KSI

Spec. Nr. Z-25
Failed on Loading

STRESS = 187 KSI

Spec. Nr. Z-29
Failed on Loading

STRESS = 195 KSI

Spec. Nr. Z-18
Failed on Loading

STRESS = 210 KSI

Spec. Nr. Z-17
Failed on Loading

TABLE X

STRESS RUPTURE DATA FOR 17-7PH TH1050 SHEET

Test Temp. (°F)	Stress (KSI)	Rupture Time (Hours)
600	165	1000 N.F.*
"	170	324.0
"	170	136.5
"	175	63.5
"	175	66.6
800	100	809
"	110	110.7
"	110	79.4
"	110	62.8
"	120	11.9

* N.F. - No Failure

TABLE XI

STRESS RUPTURE DATA FOR AM350 SCT SHEET

Test Temp. (°F)	Stress (KSI)	Rupture Time (Hours)
500	190	1000 N.F.*
"	194	1000 N.F.
"	195.5	Failed on Loading
"	197	Failed on Loading
"	205	Failed on Loading
800	185	888.8
"	190	715.4
"	191.25	Failed on Loading
"	192.5	Failed on Loading
"	195	Failed on Loading

* N.F. - No Failure

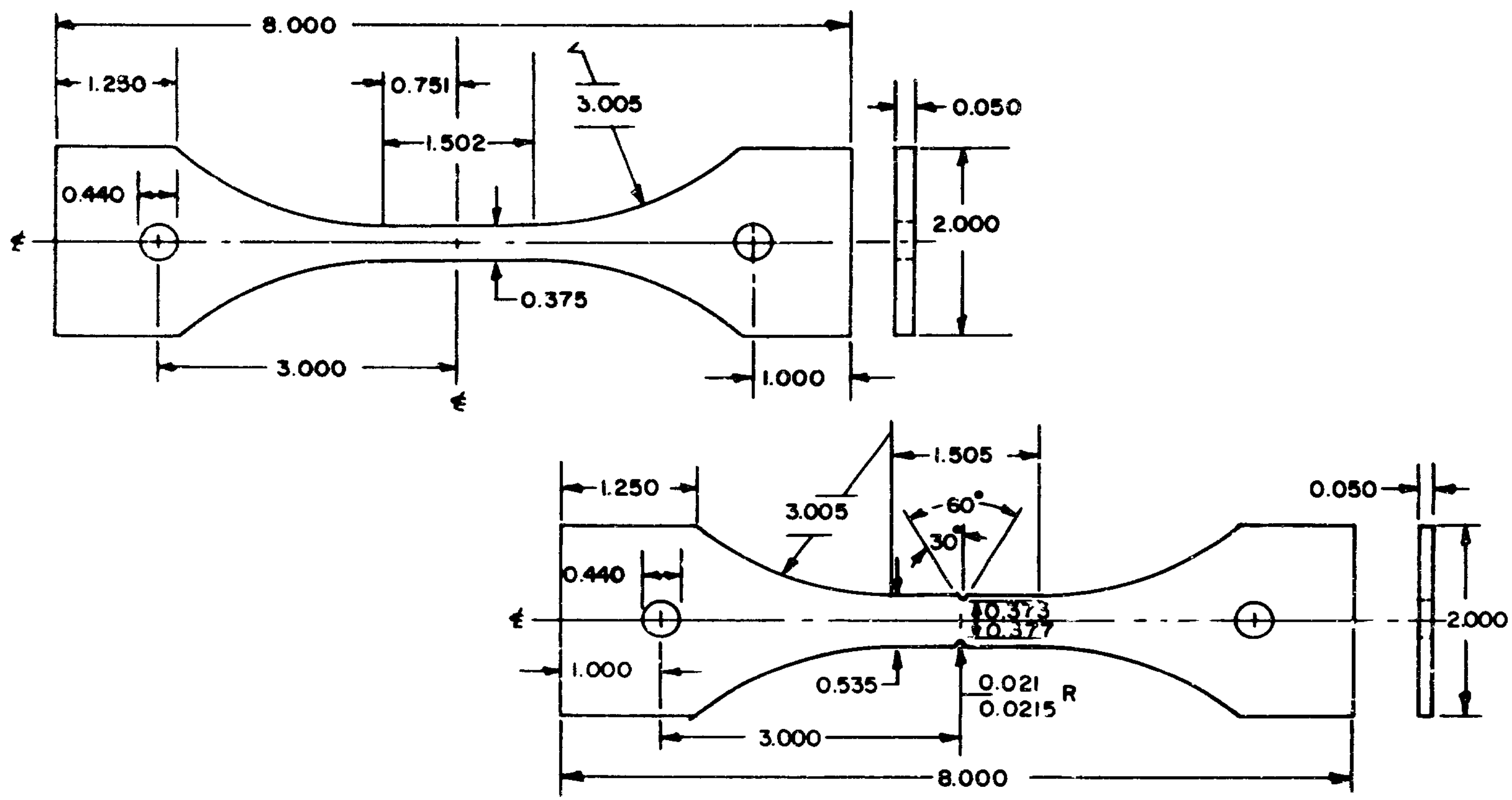

Figure 1. Smooth and Notched (K_t=3.0) Test Specimens

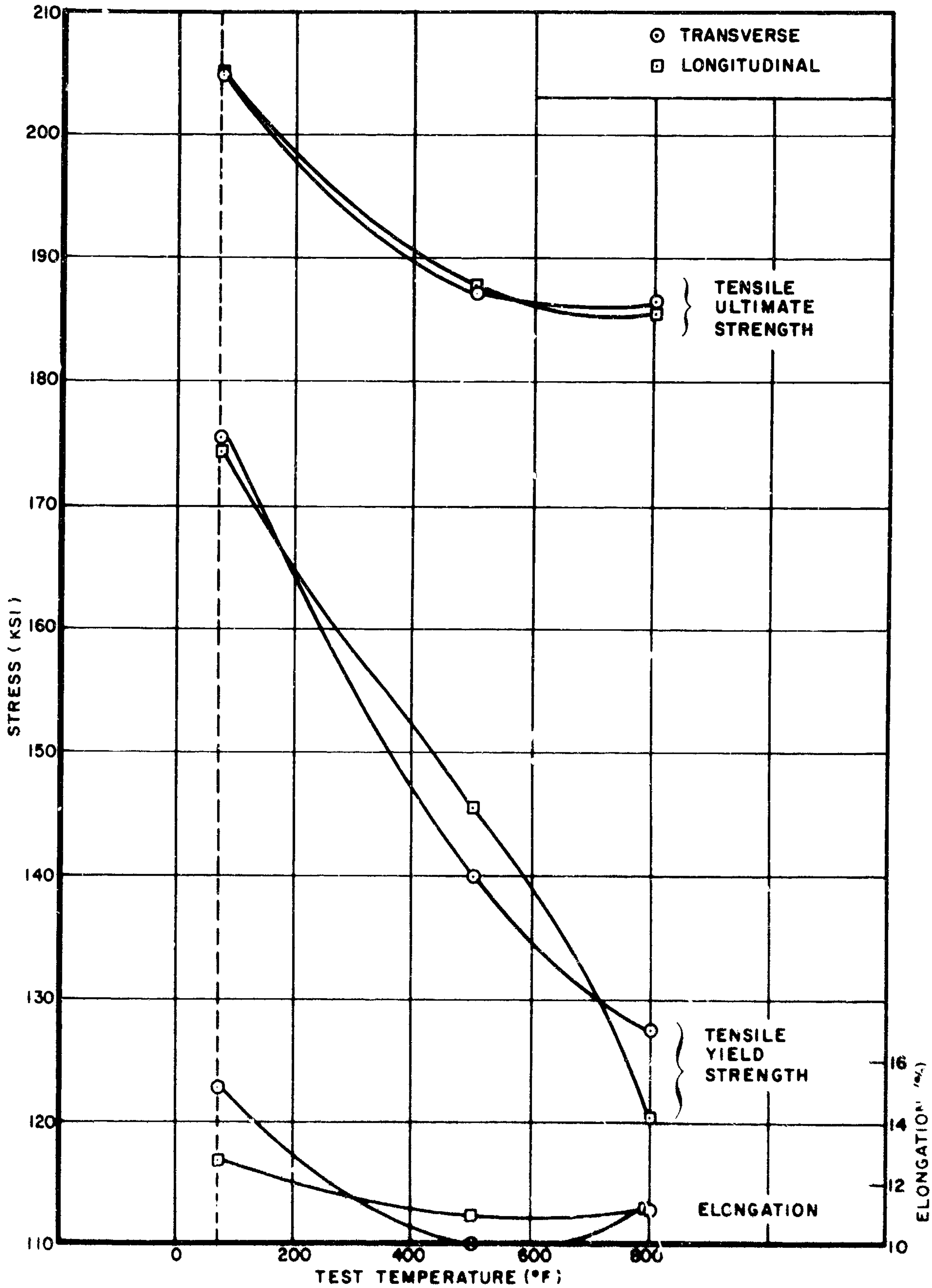

Figure 3. Tensile Properties Vs. Temperature for AM 350

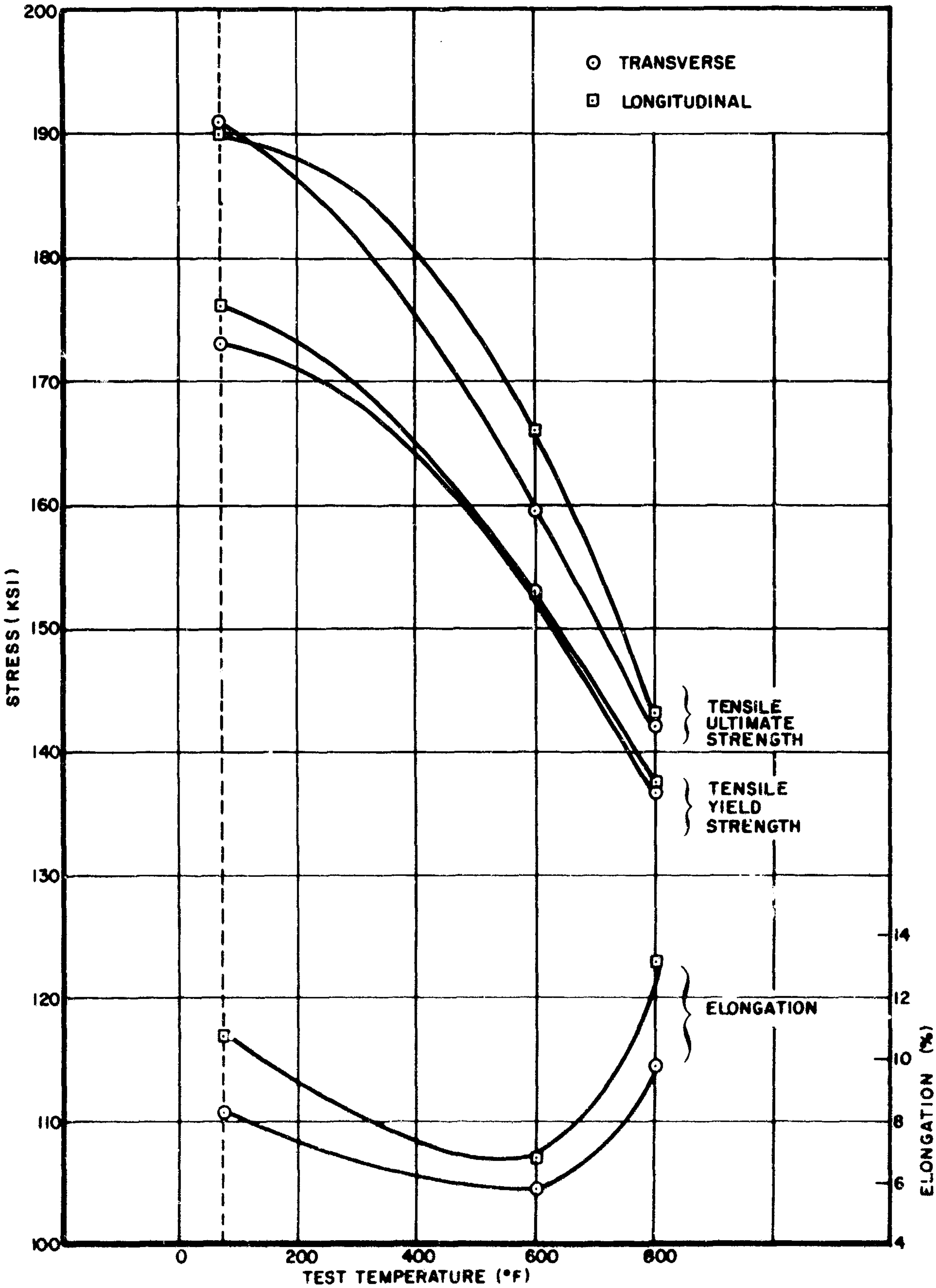

Figure 2. Tensile Properties Vs. Temperature for 17-7 PH

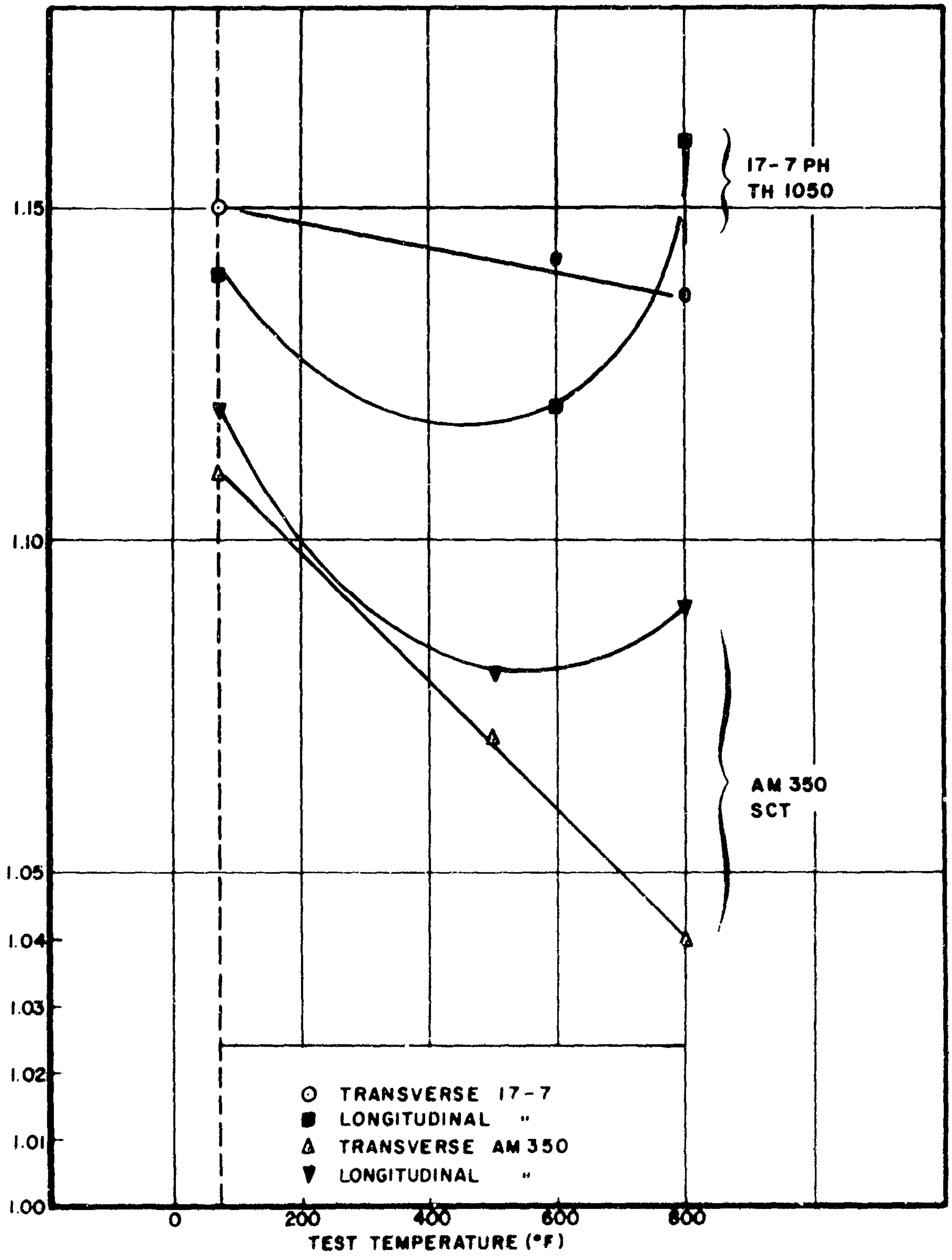

Figure 4. Notched Specimen Ratio (%)

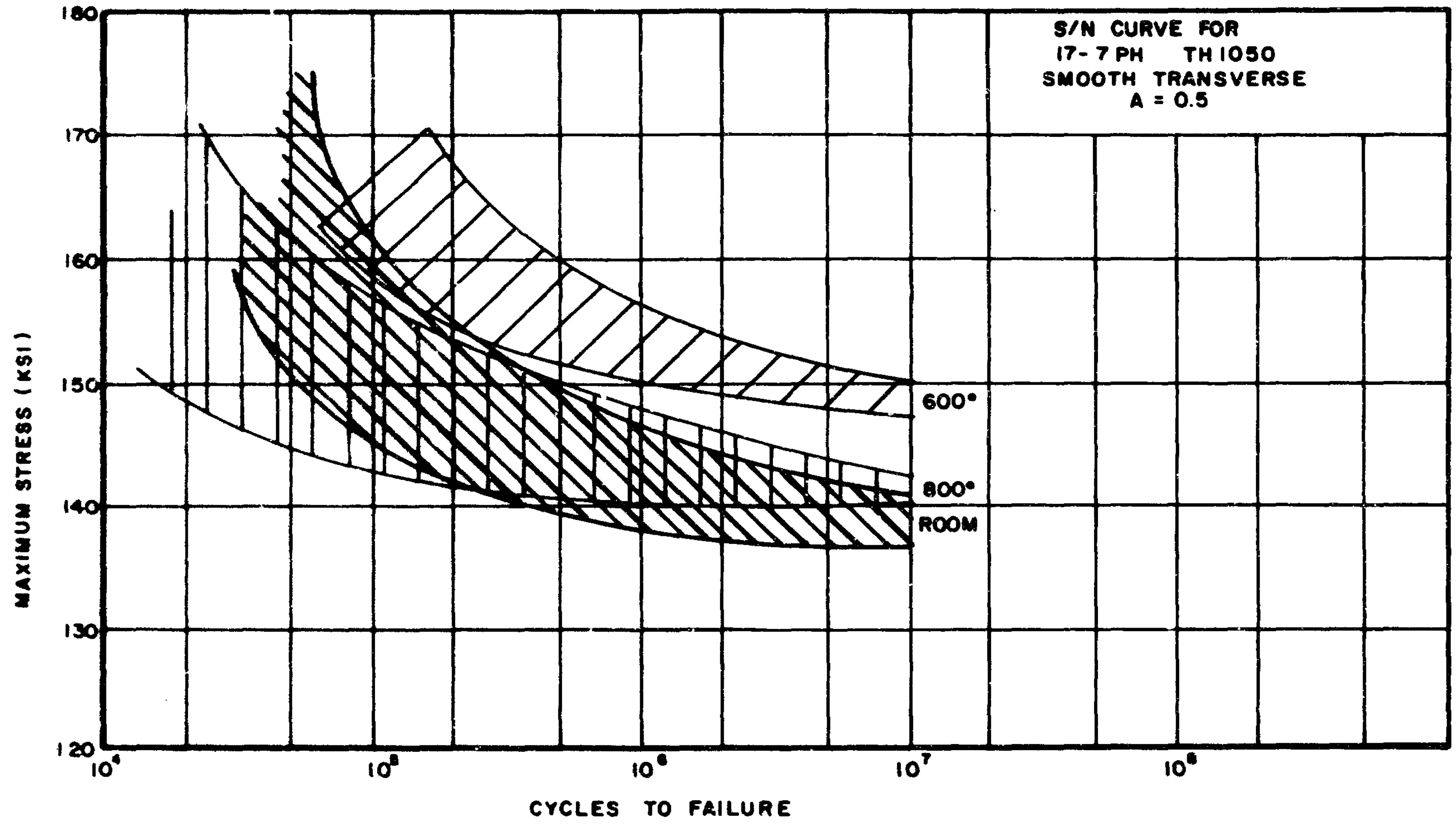

Figure 5. S/N Curve for 17-7 PH TH 1050, Smooth Transverse, A=0.5

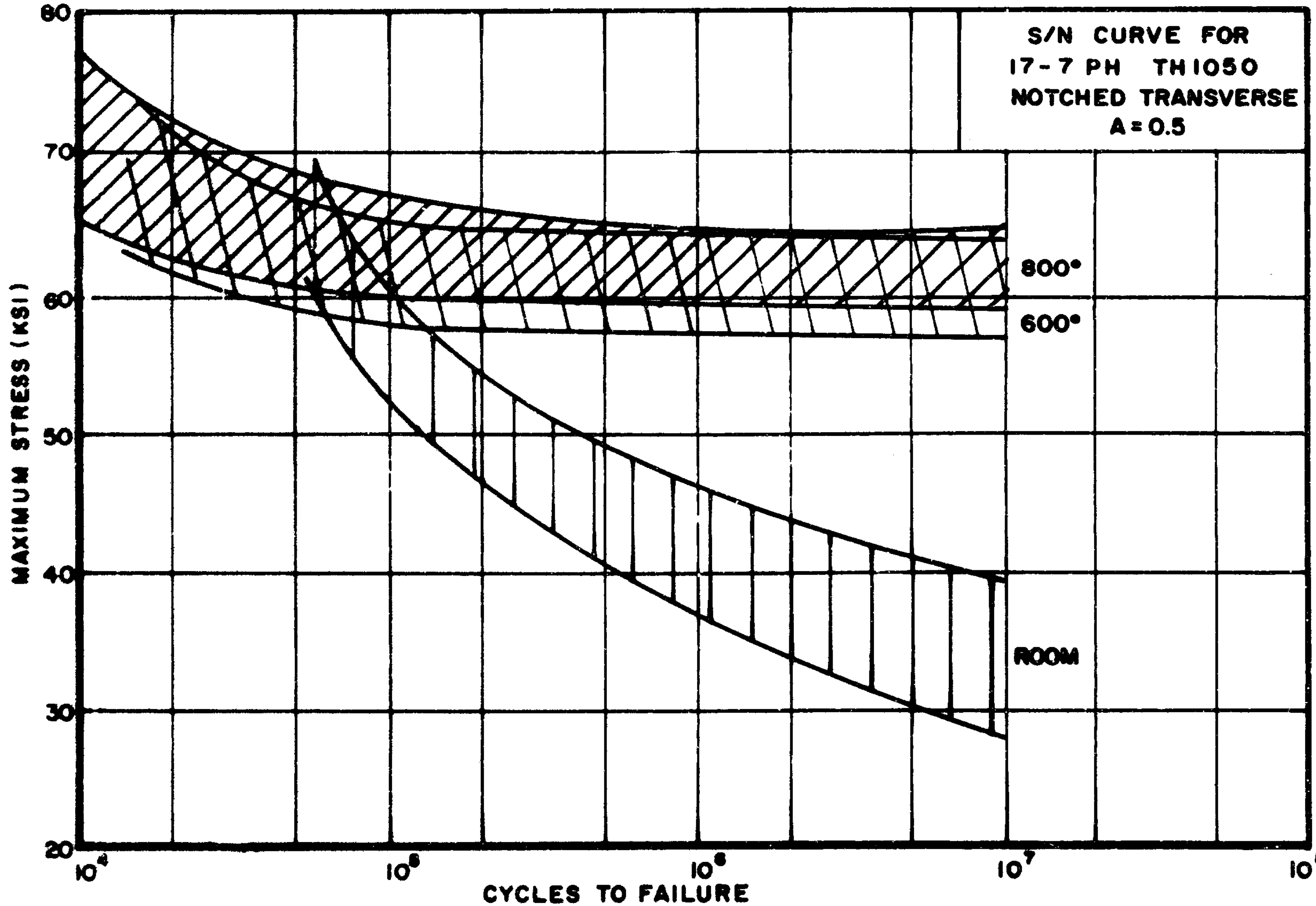

Figure 6. S/N Curve for 17-7 PH TH 1050, Notched Transverse, A=0.5

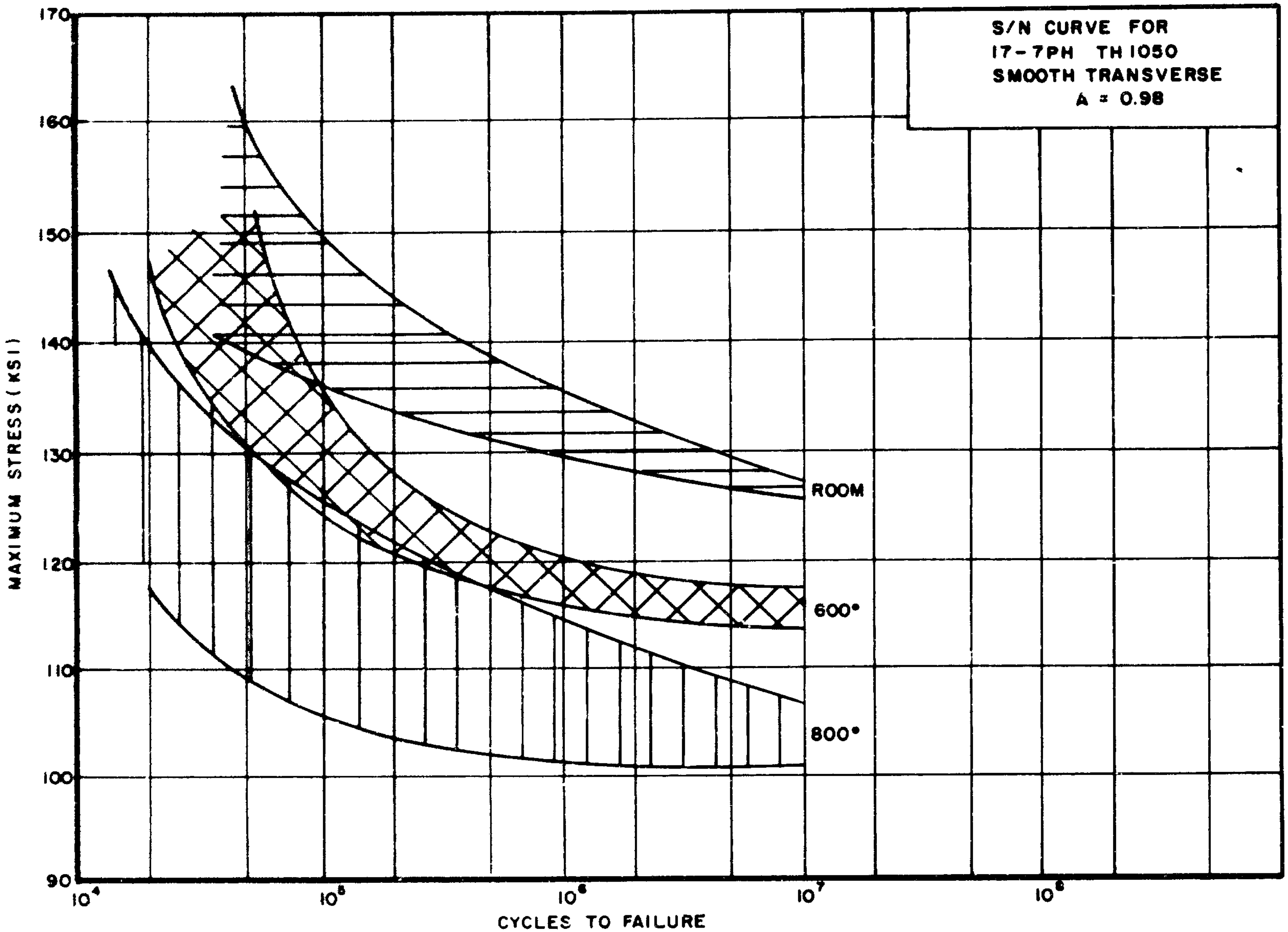

Figure 7. S/N Curve for 17-7 PH TH 1050, Smooth Transverse, A=0.98

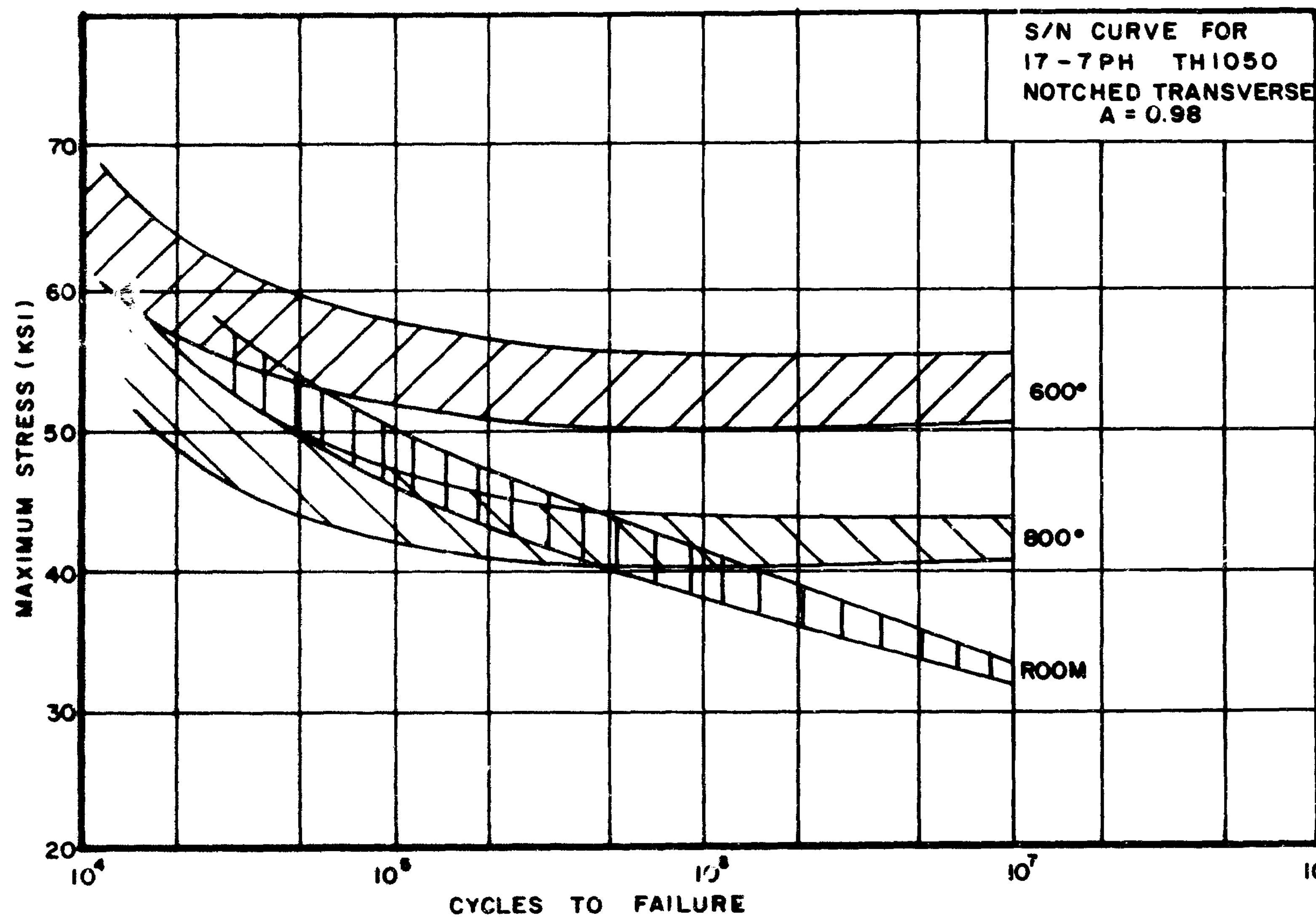

Figure 8. S/N Curve for 17-7 PH TH 1050, Notched Transverse, A=0.98

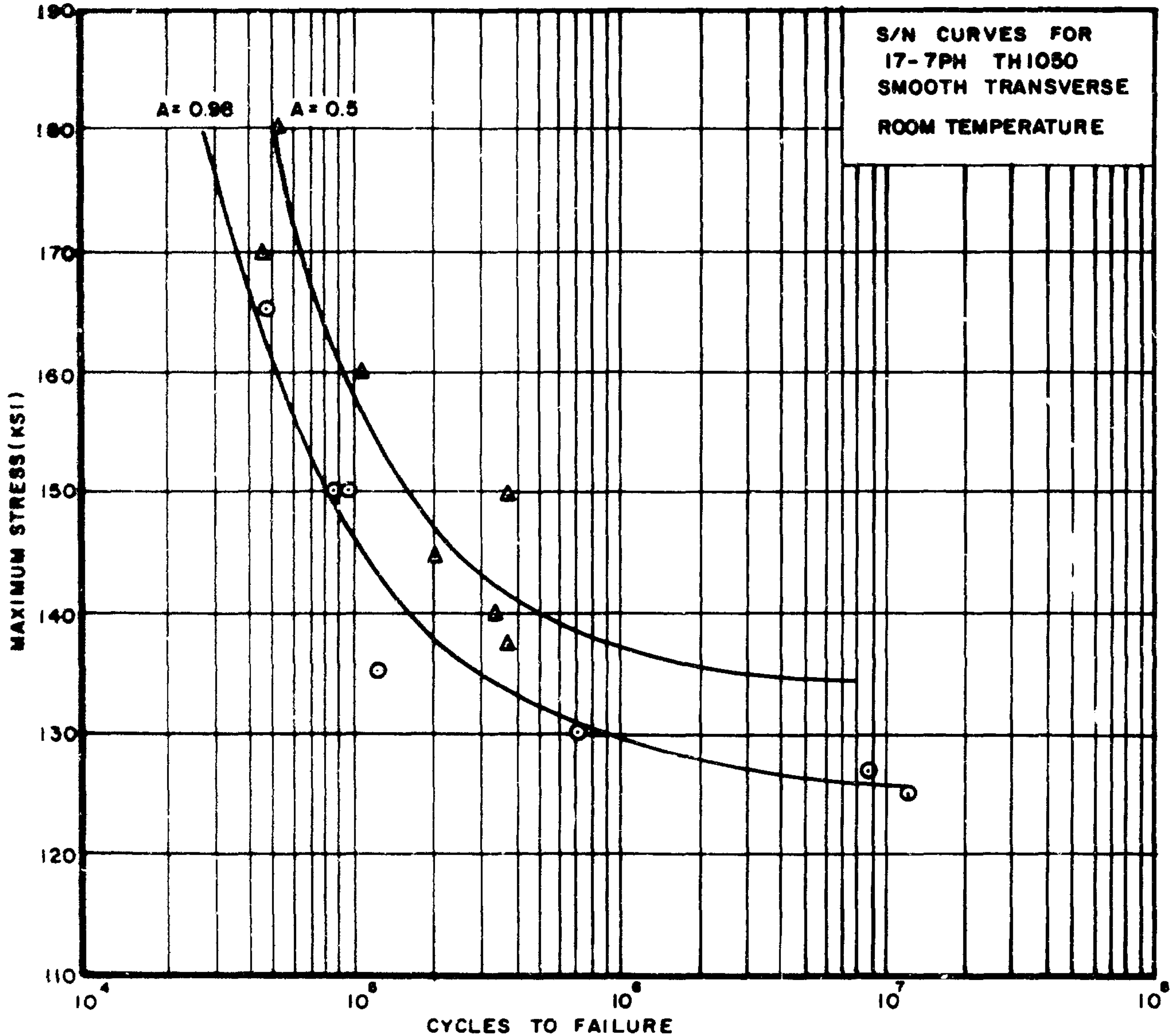

Figure 9. S/N Curves for 17-7 PH TH 1050, Smooth Transverse, Room Temperature

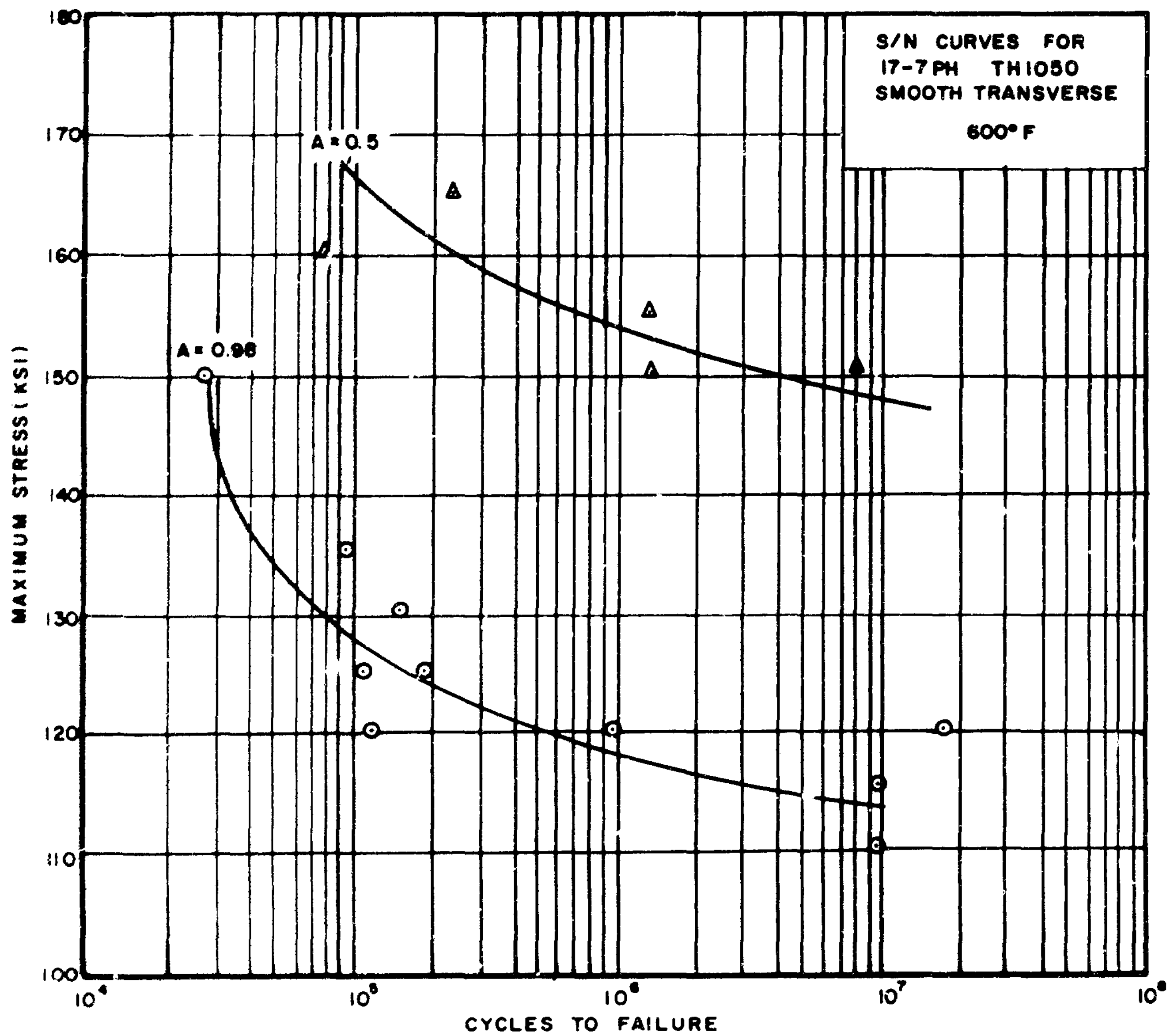

Figure 10. S/N Curves for 17-7 PH TH 1050, Smooth Transverse, 700° F

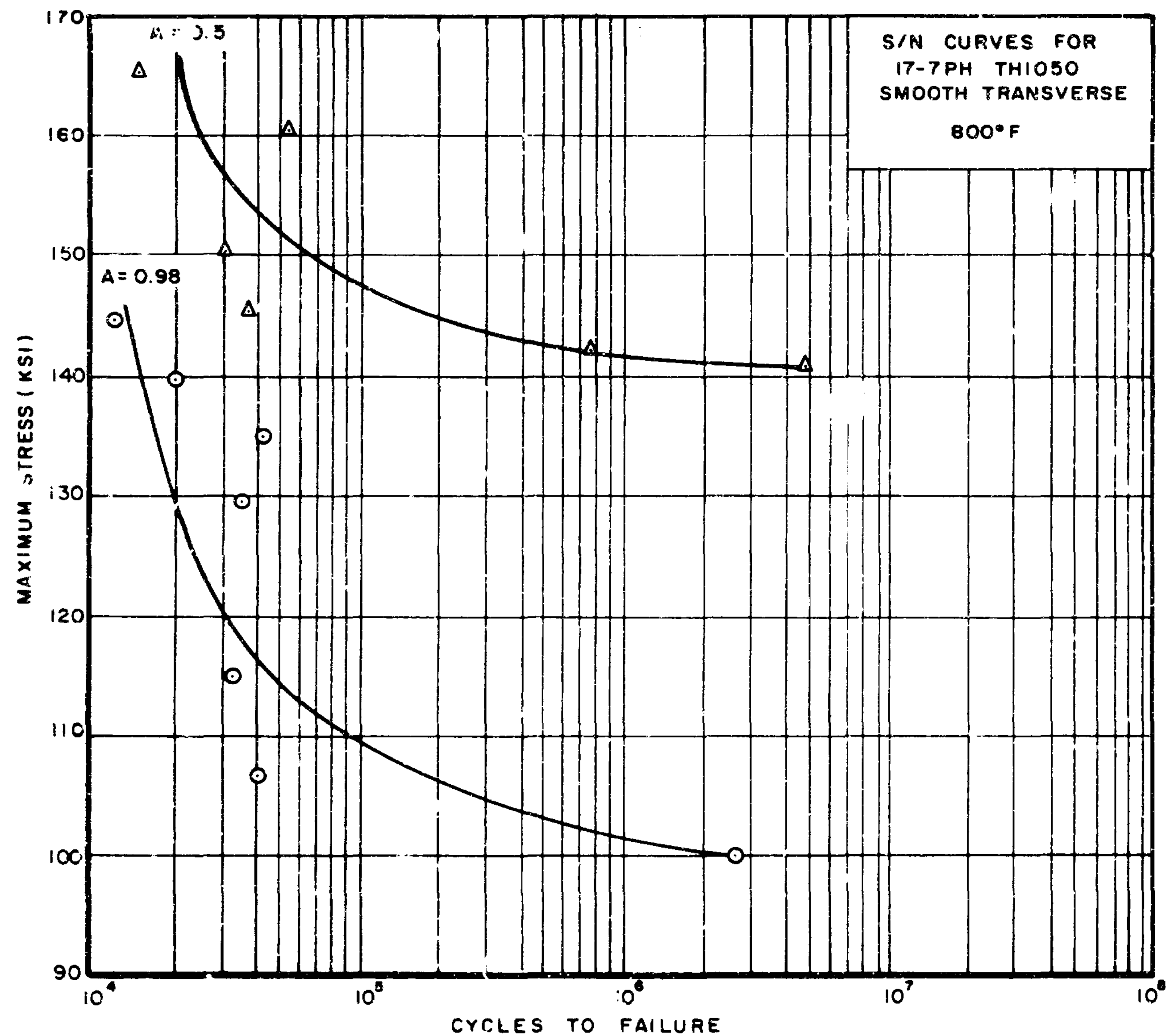

Figure 11. S/N Curves for 17-7 PH TH 1050, Smooth Transverse, 800°F

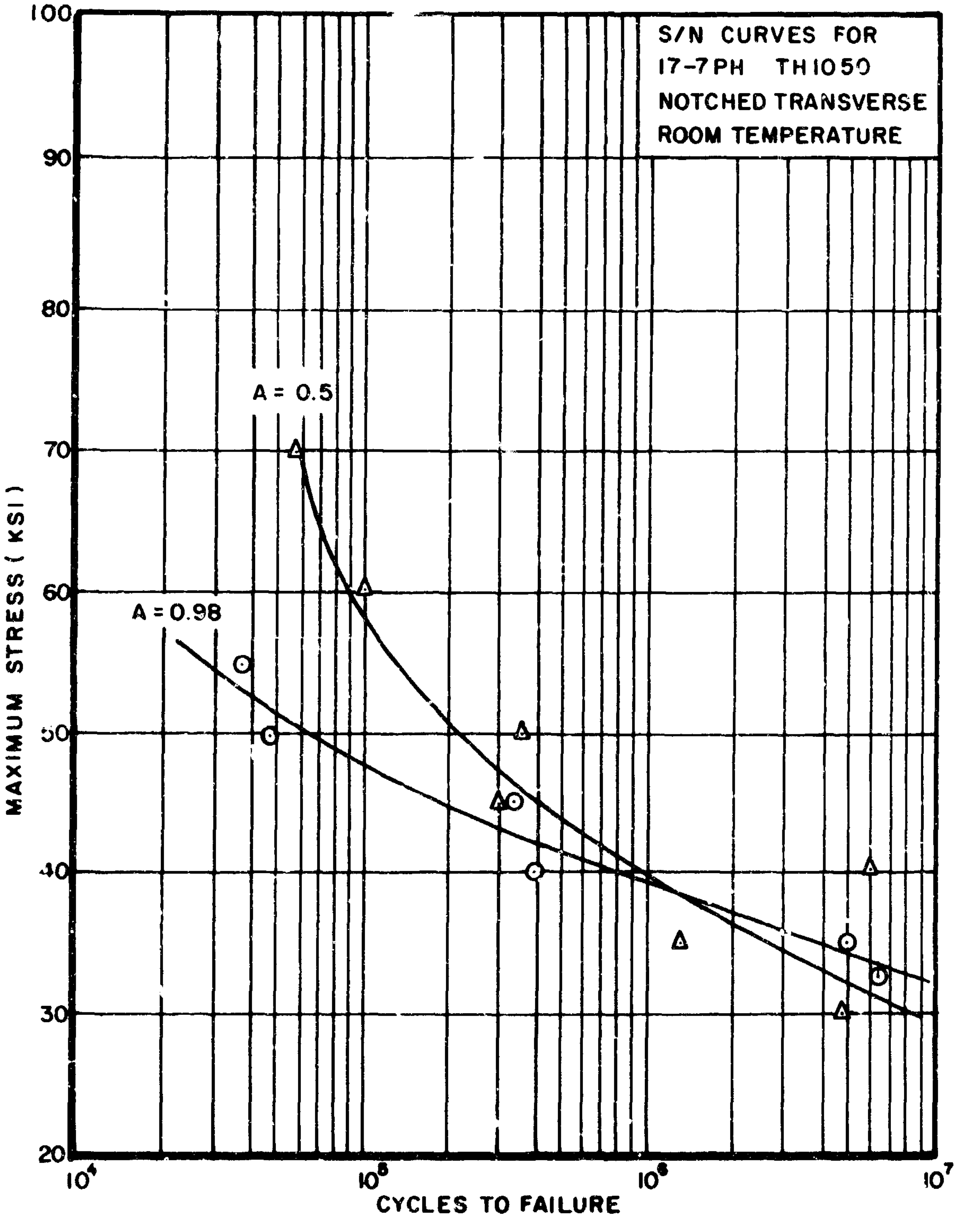

Figure 12. S/N Curves for 17-7 PH TH 1050, Smooth Transverse, Room Temperature

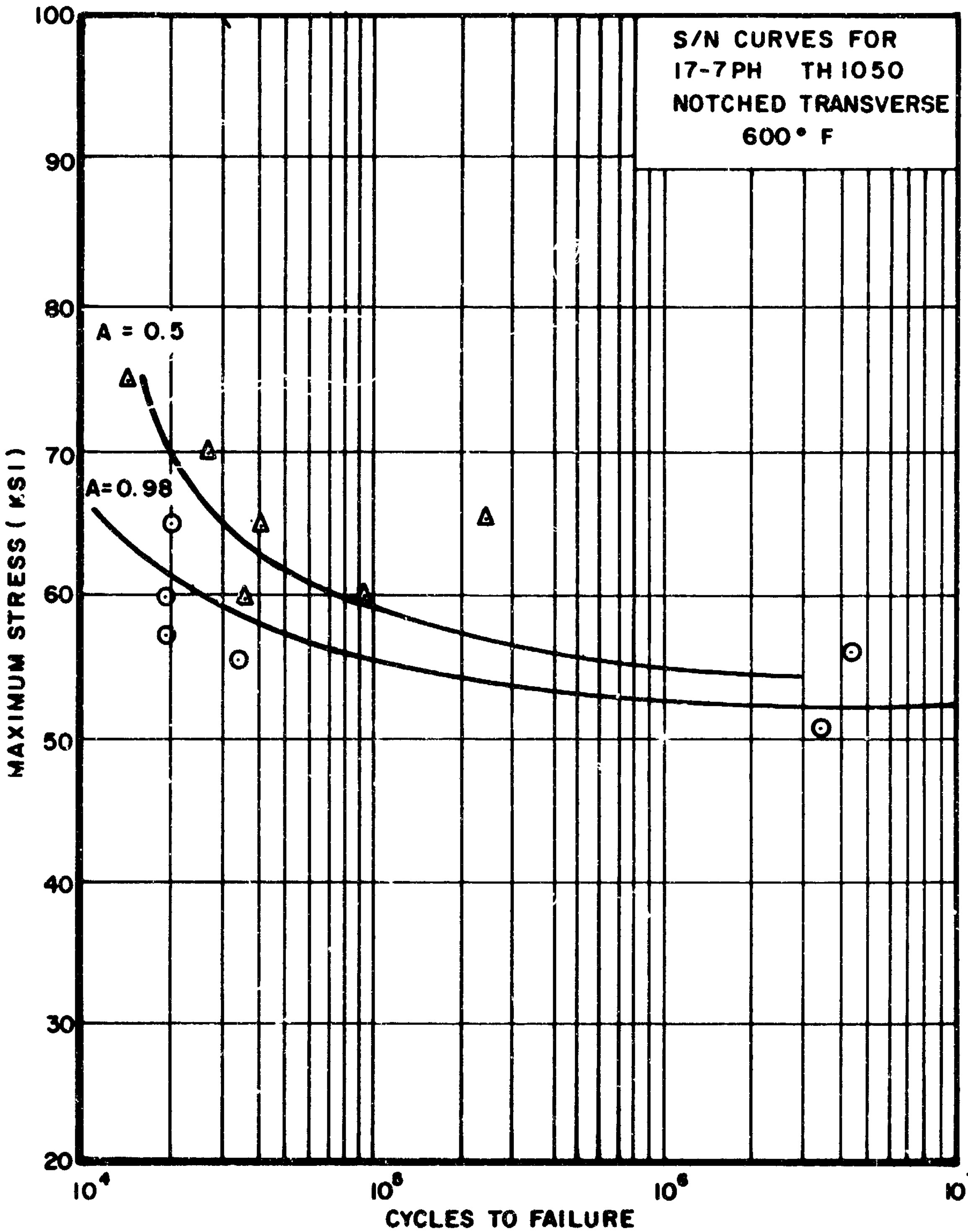

Figure 13. S/N Curves for 17-7 PH TH 1050, Notched Transverse, 600°F

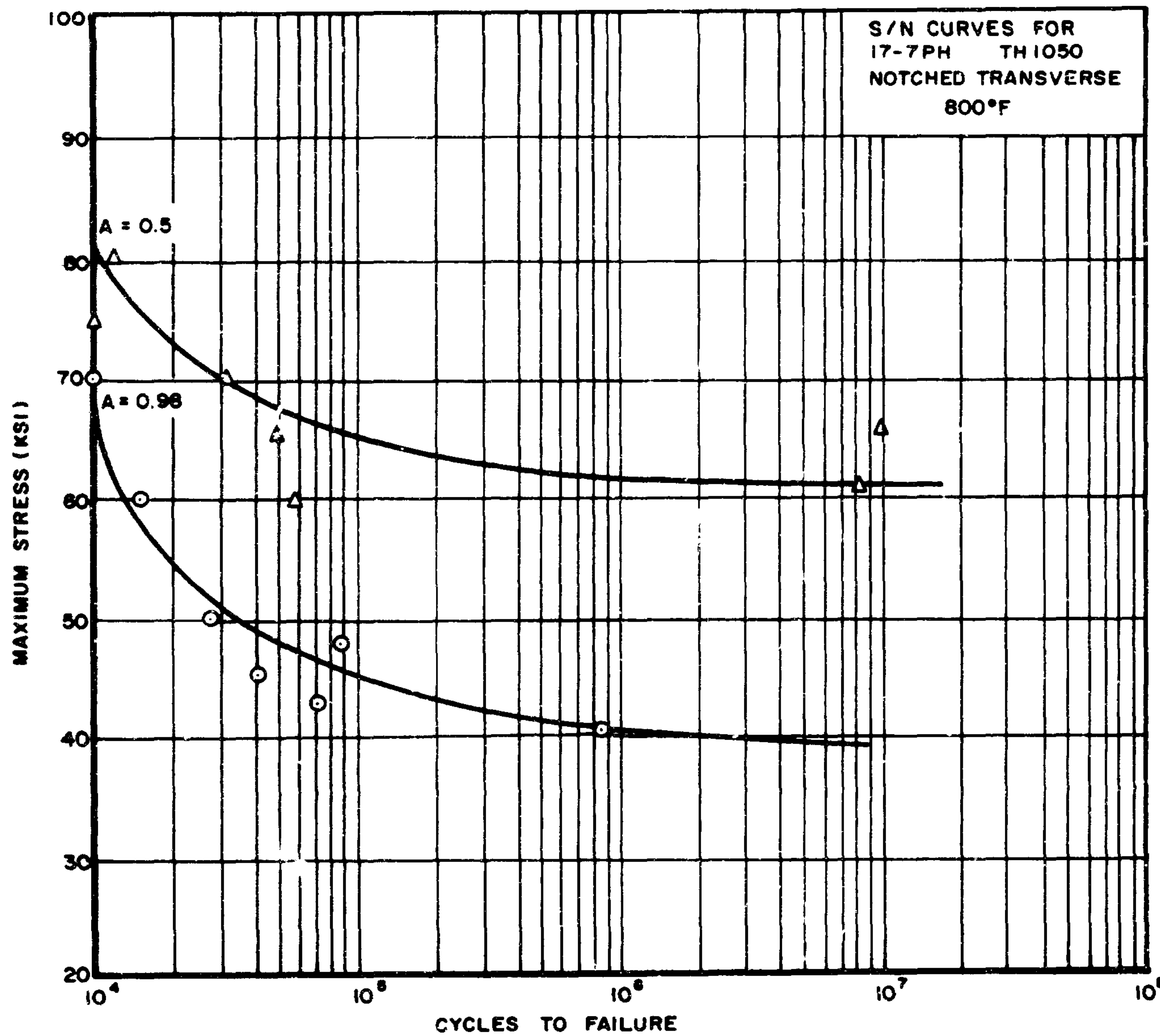

Figure 14. S/N Curves for 17-7 PH TH 1050, Notched Transverse, 800°F

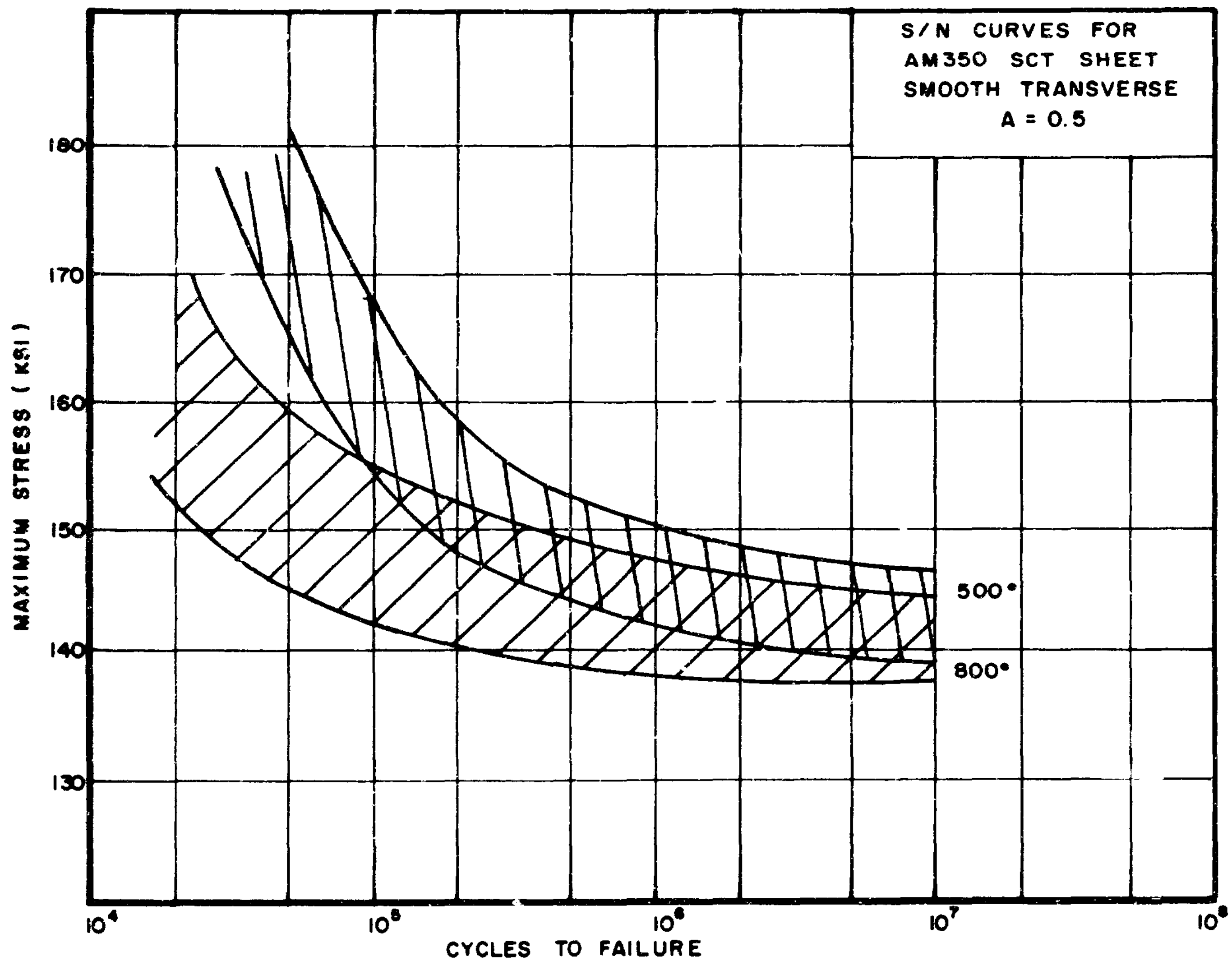

Figure 15. S/N Curve for AM 350 SCT Sheet, Smooth Transverse, A=0.5

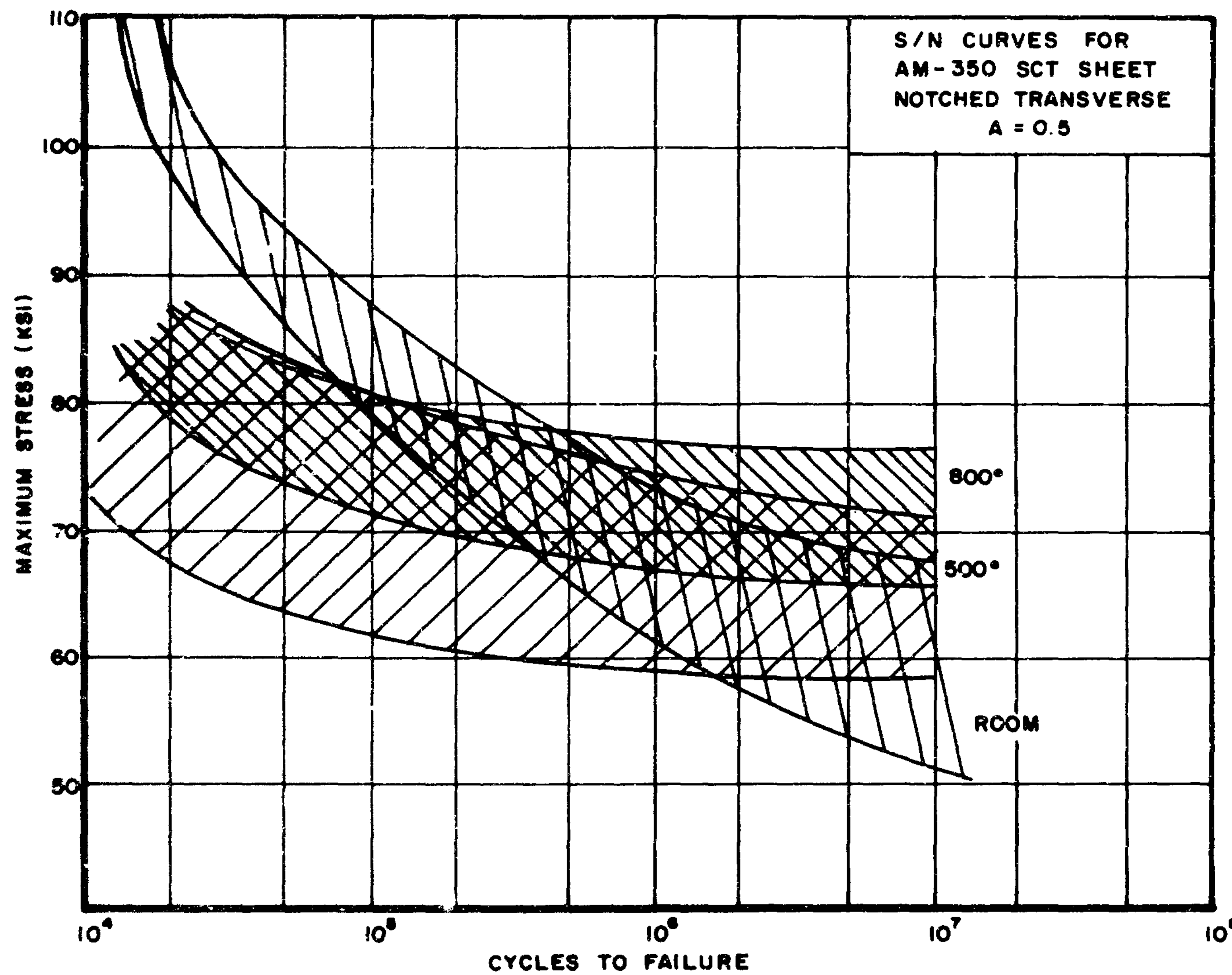

Figure 16. S/N Curve for AM 350 SCT Sheet, Notched Transverse, A=0.5

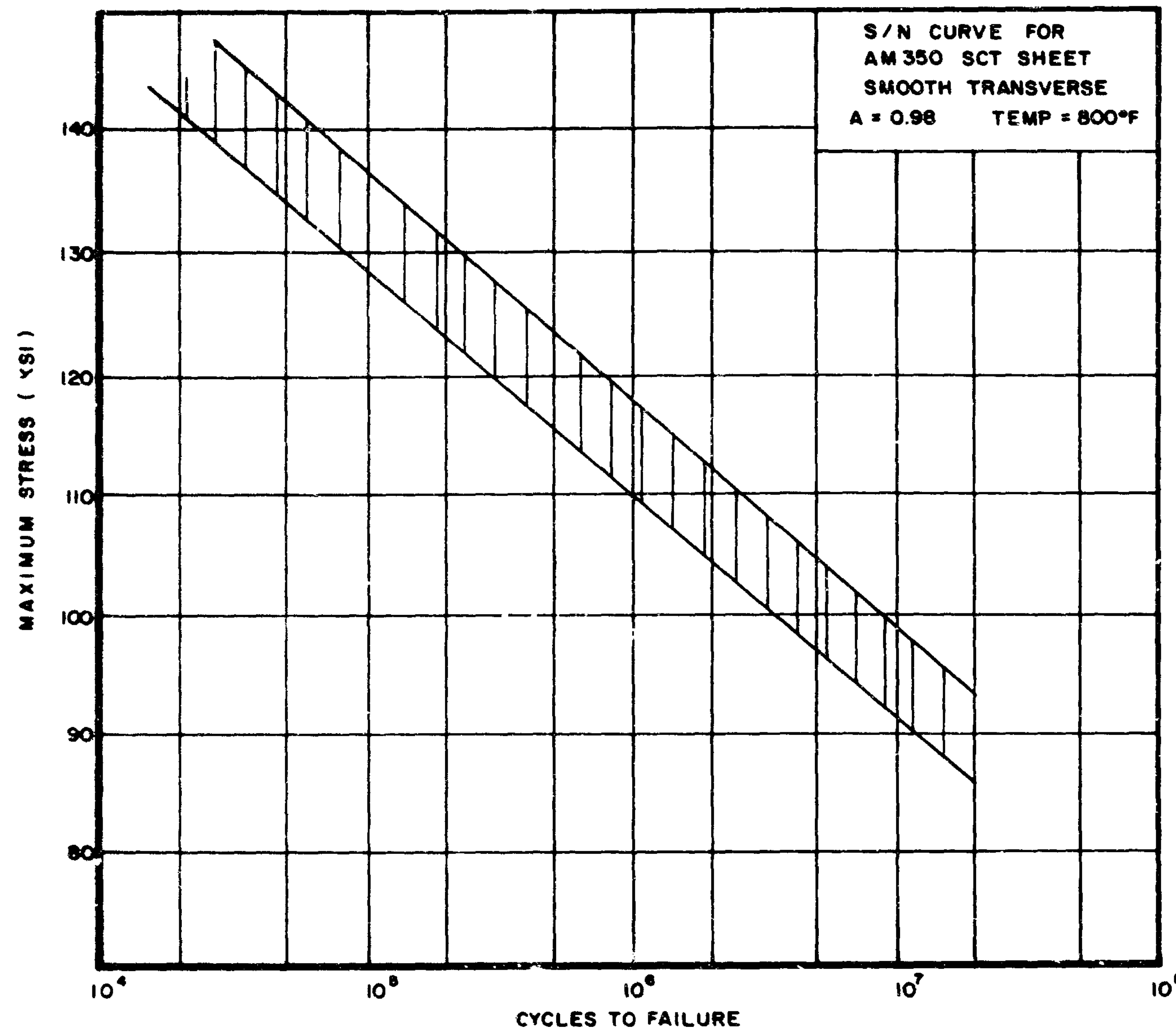

Figure 17. S/N Cur/e for AM 350 SCT Sheet, Smooth Transverse, A=0.98, 800°F

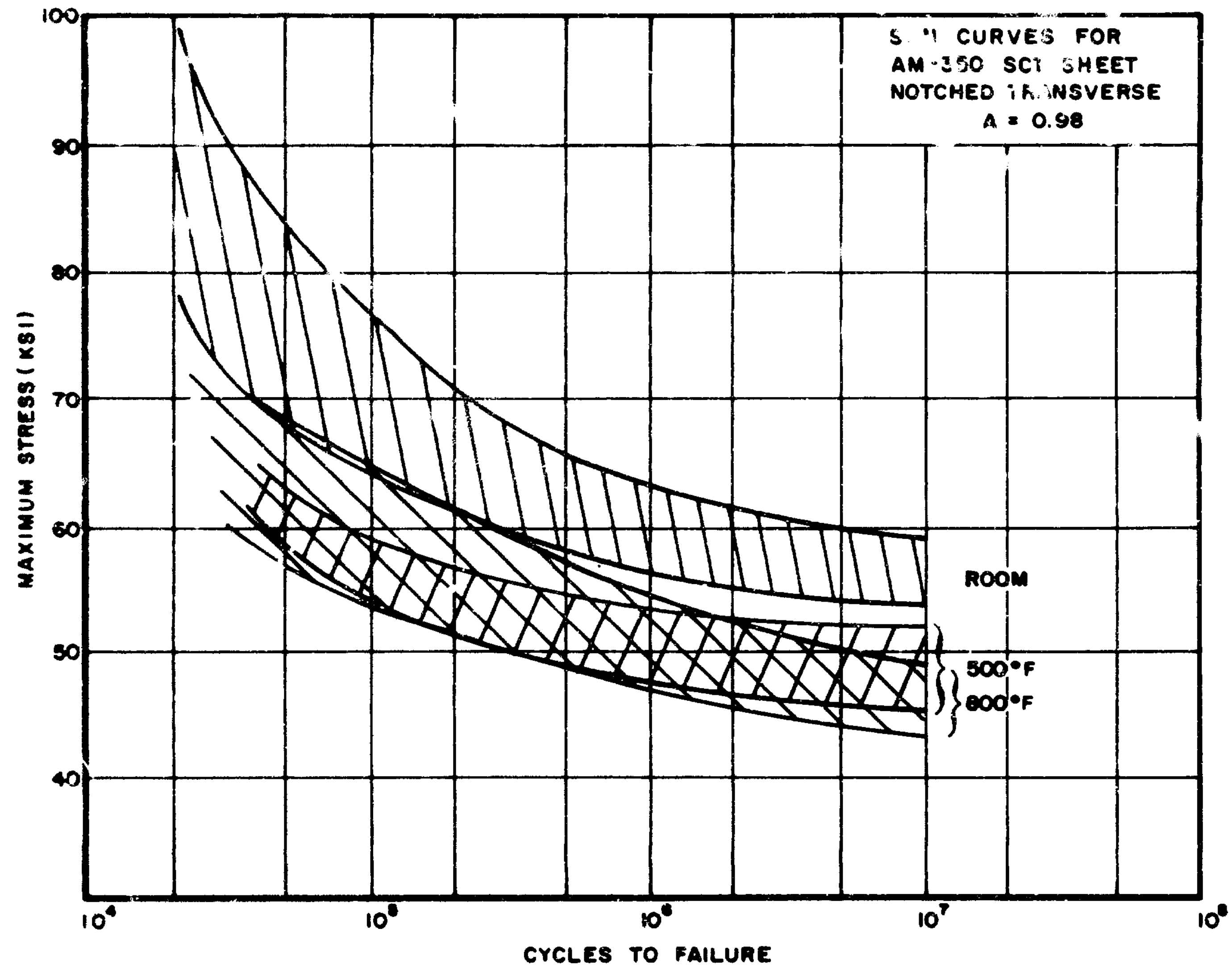

Figure 18. S/N Curve for AM 350 SCT Sheet, Notched Transverse, A=0.98

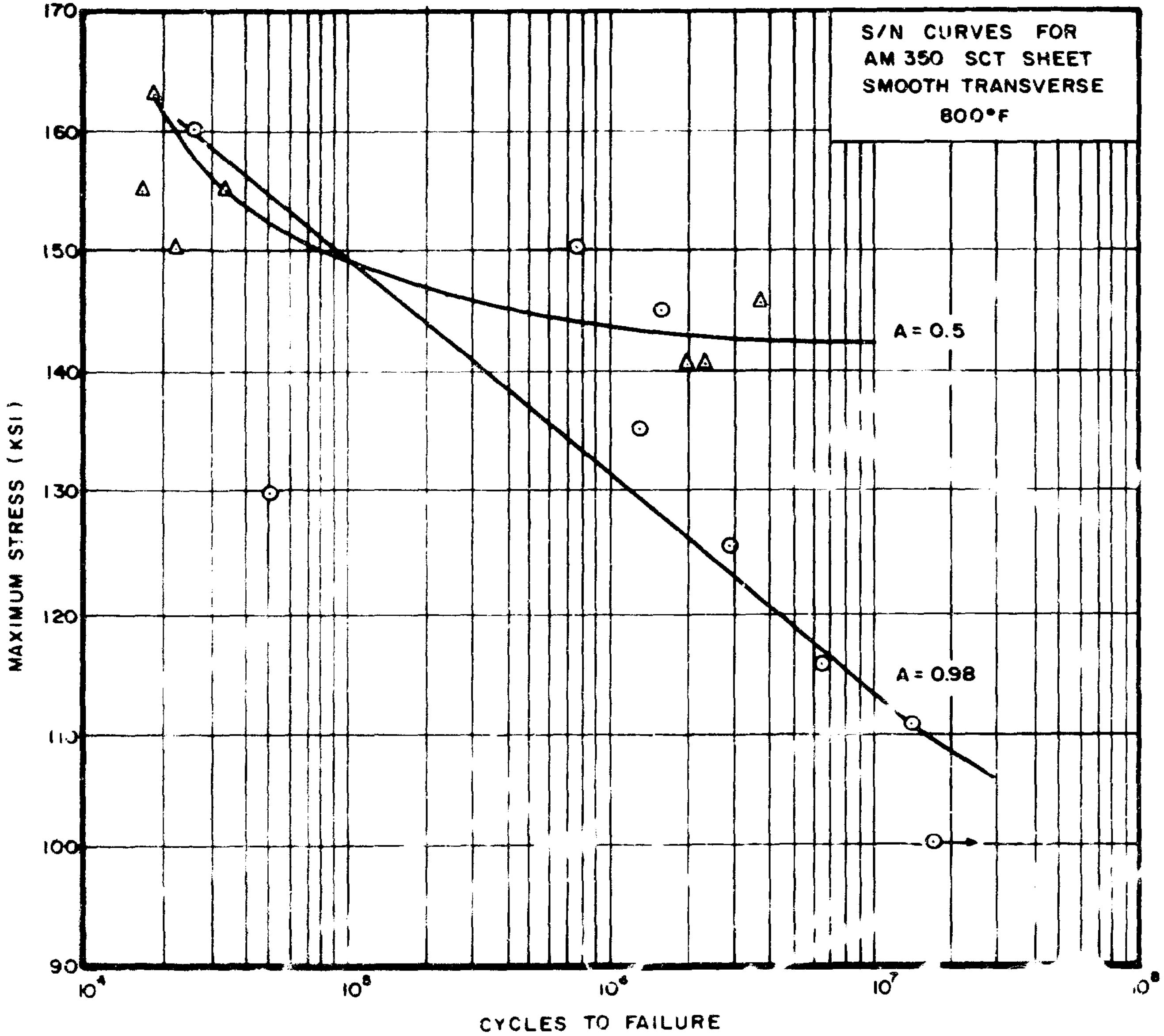

Figure 19. S/N Curve for AM 350 SCT Sheet, Smooth Transverse 800° F

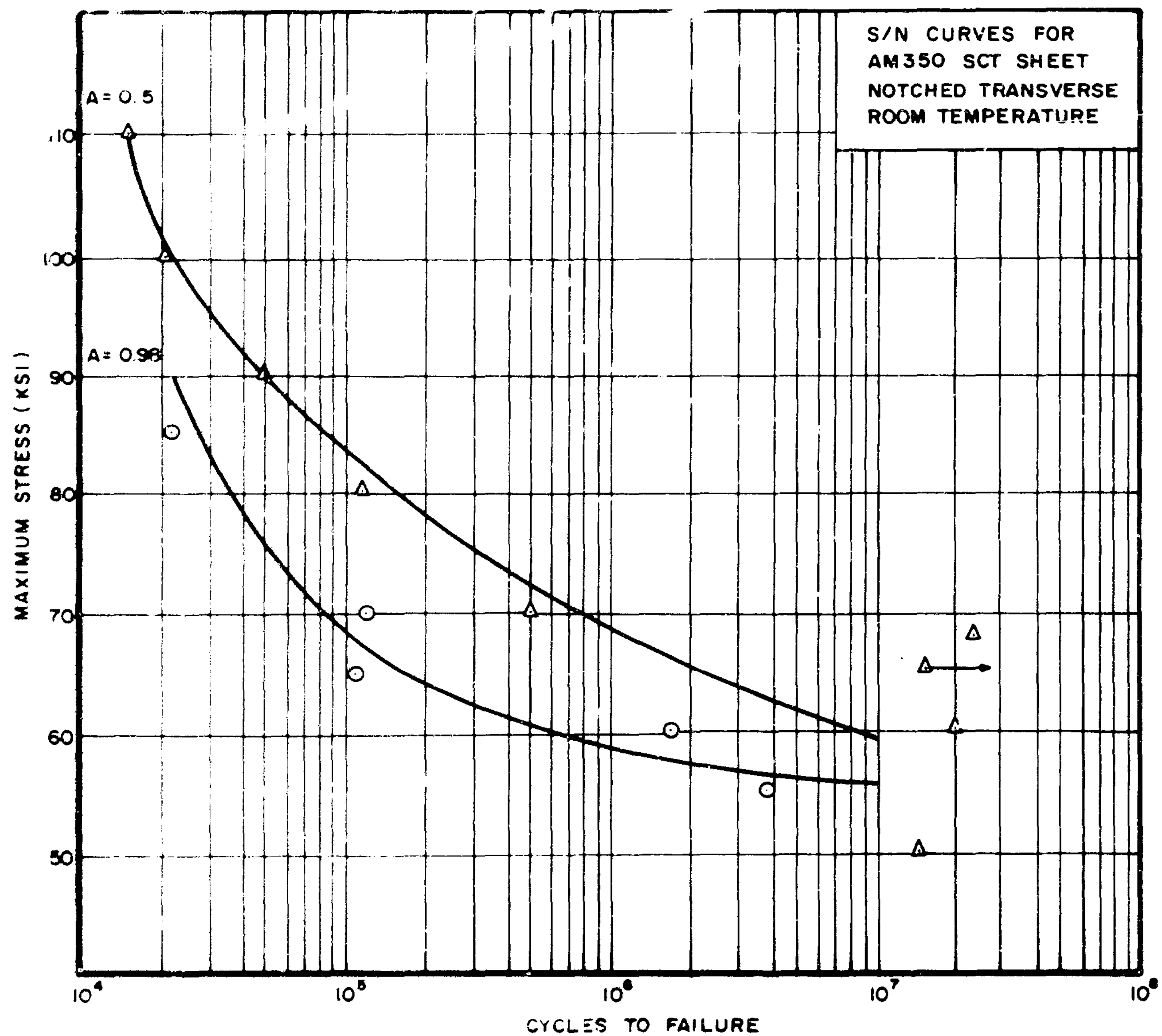

Figure 20. S/N Curve for AM 350 SCT Sheet, Notched Transverse, Room Temperature

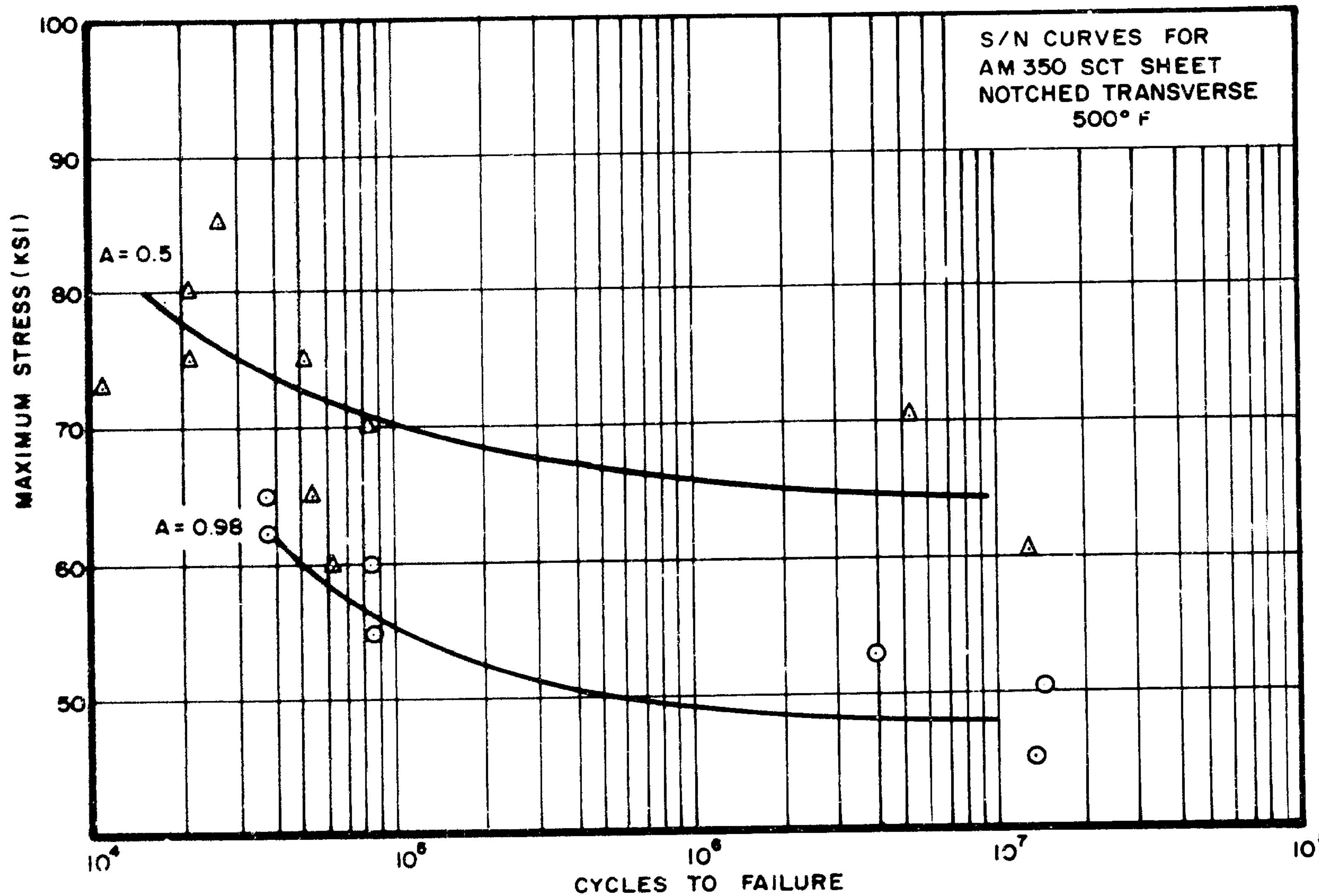

Figure 21. S/N Curves for AM 350 SCT Sheet, Notched Transverse, 500°F

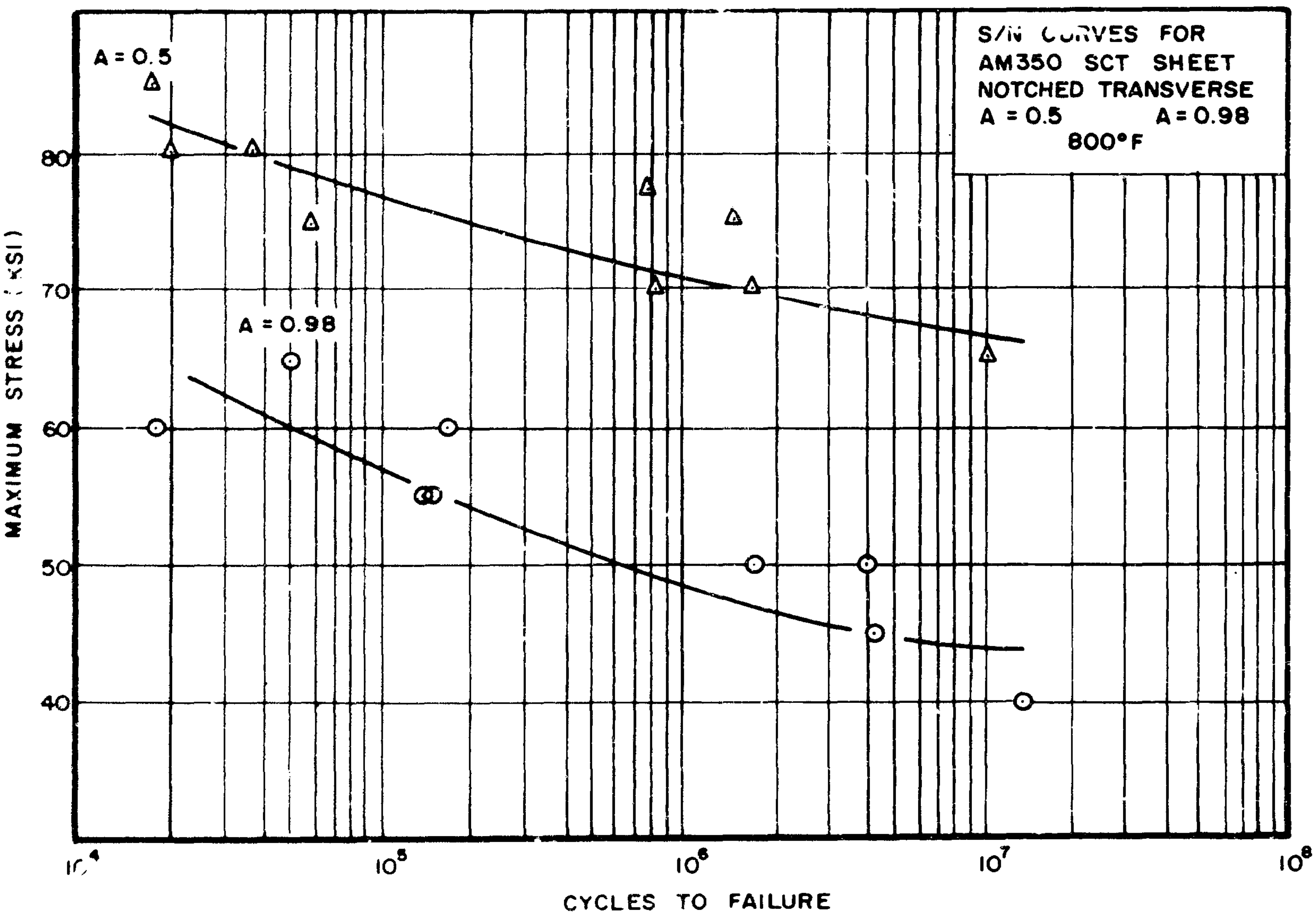

Figure 22. S/N Curves for AM 350 SCT Sheet, Notched Transverse, A=0.5, A=0.98, 800°F

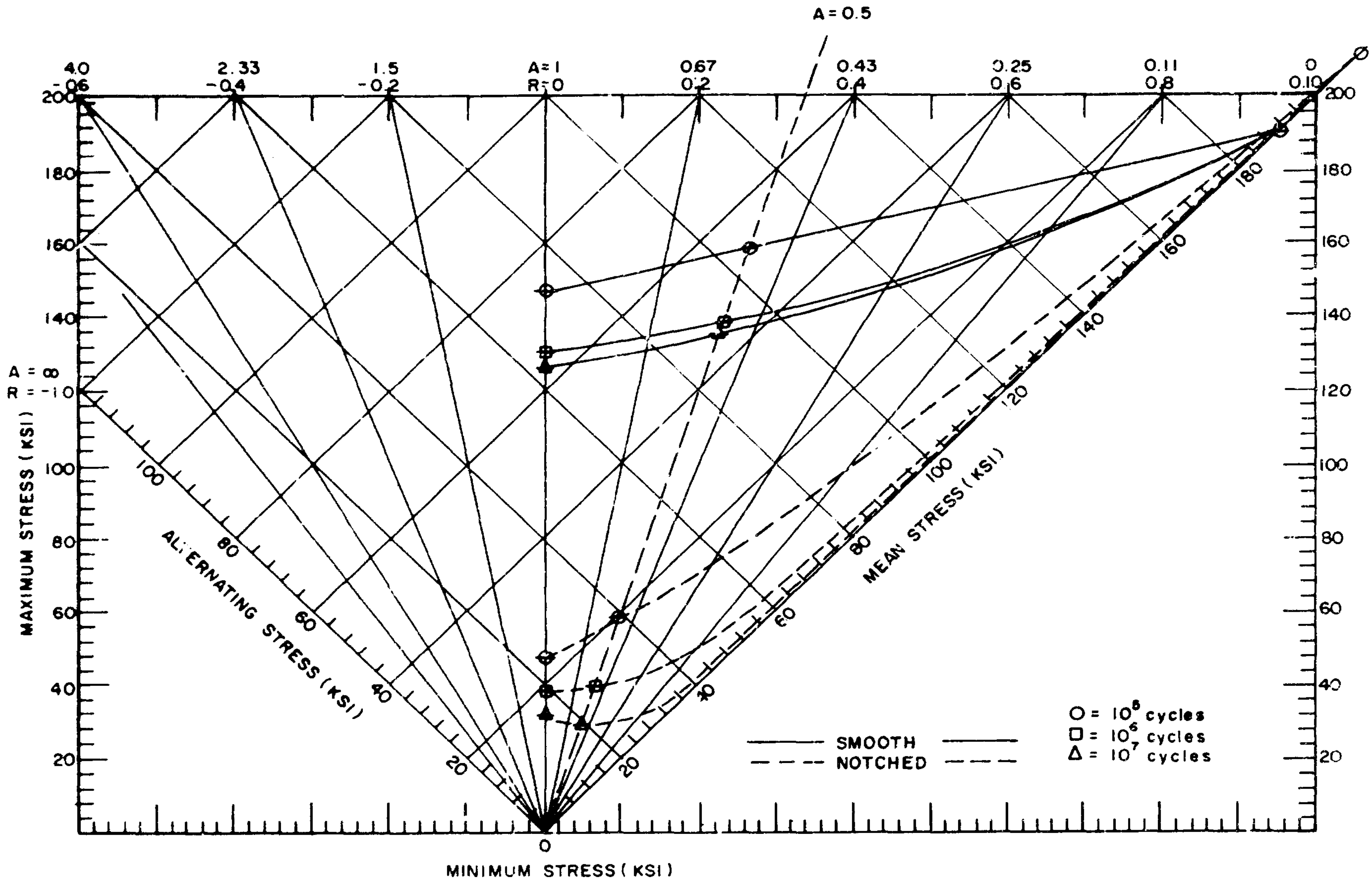

Figure 23. Constant Life Diagram for 17-7 PH TH 1050, Transverse, Room Temperature

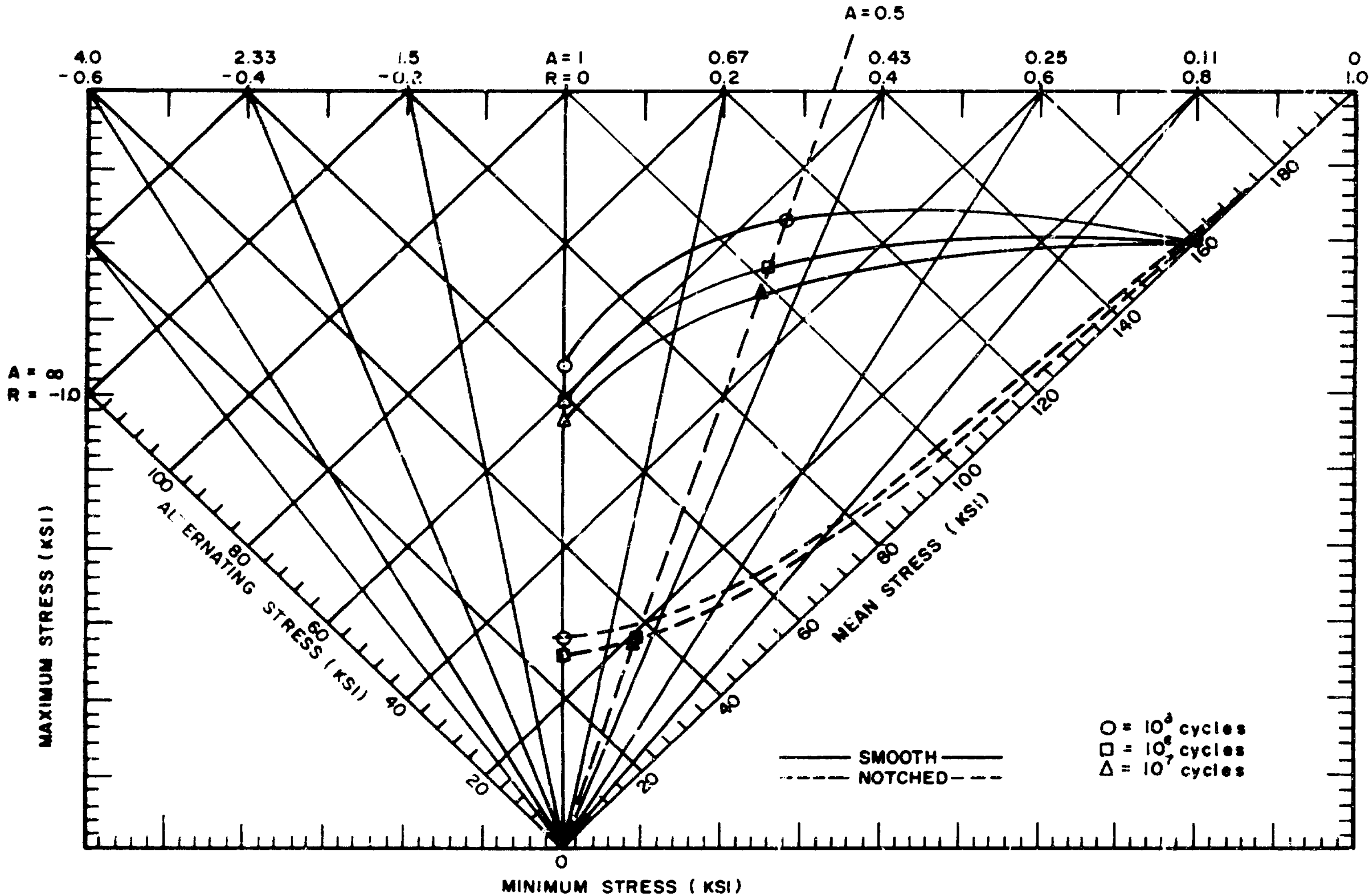

Figure 24. Constant Life Diagram for 17-7 PE TH 1050, Transverse, 600°F

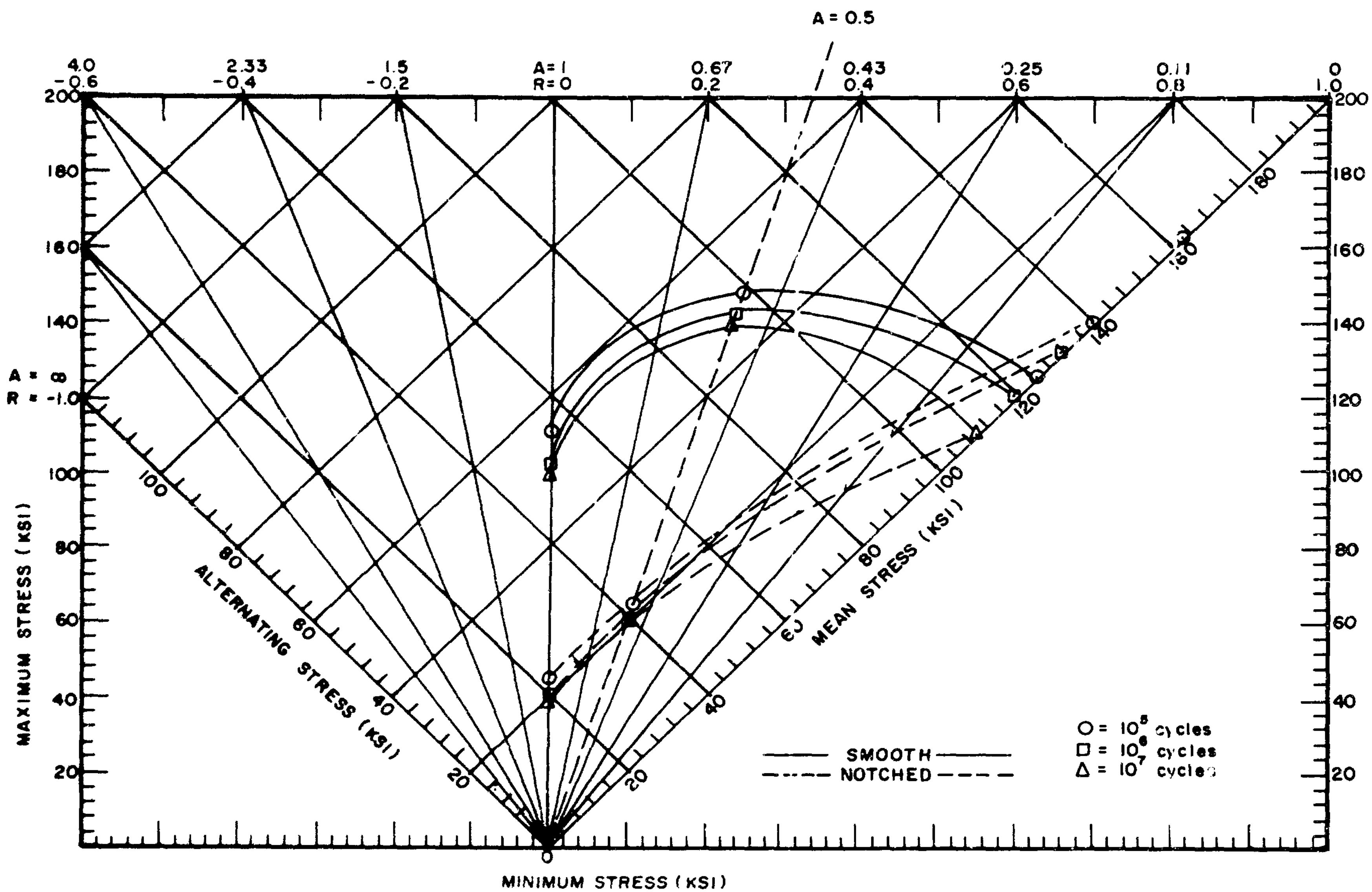

Figure 25. Constant Life Diagram for 17-7 PH TH 1050, Transverse, 800°F

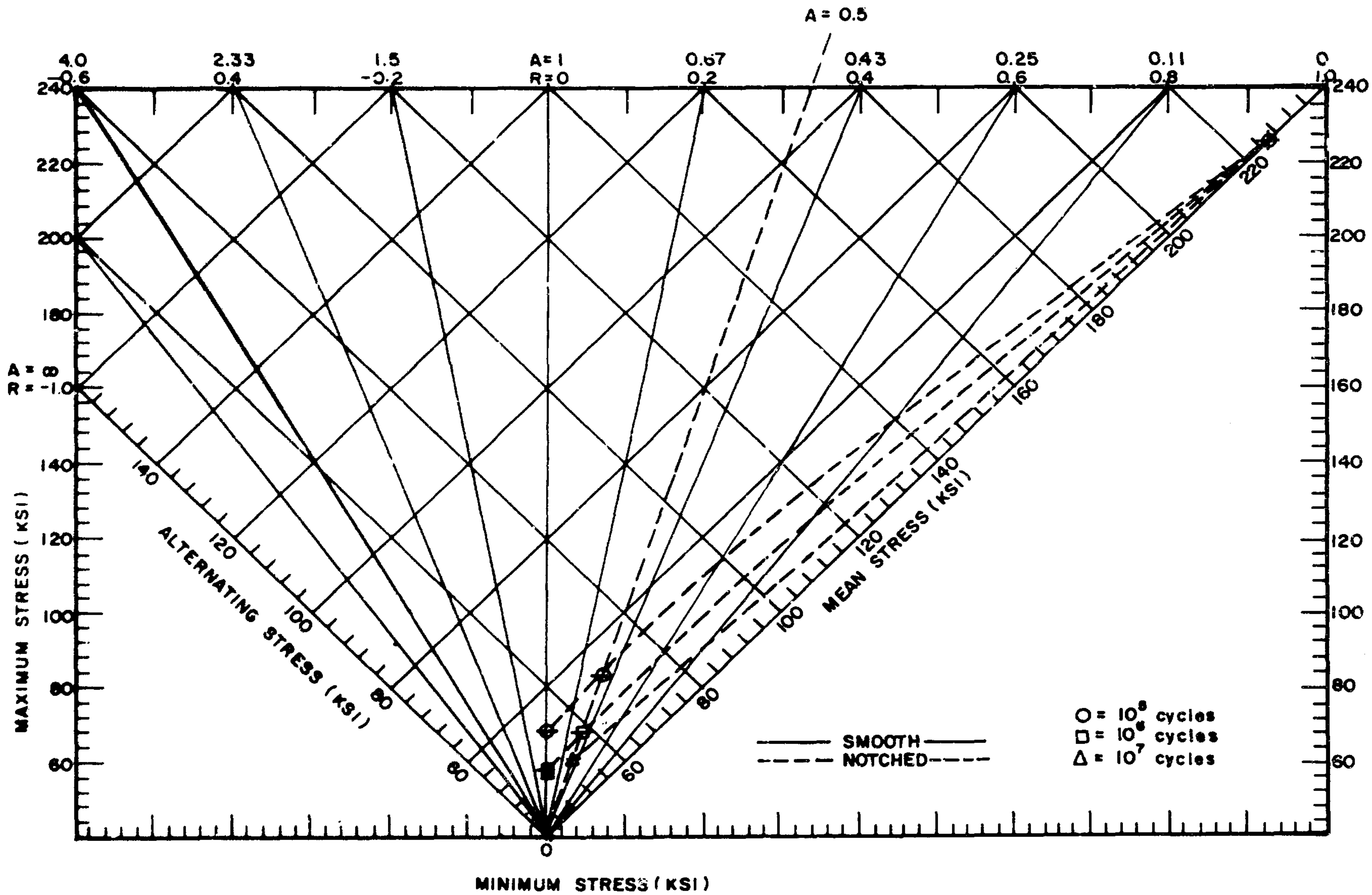

Figure 26. Constant Life Diagram for AM 350 SCT Sheet, Transverse, Room Temperature

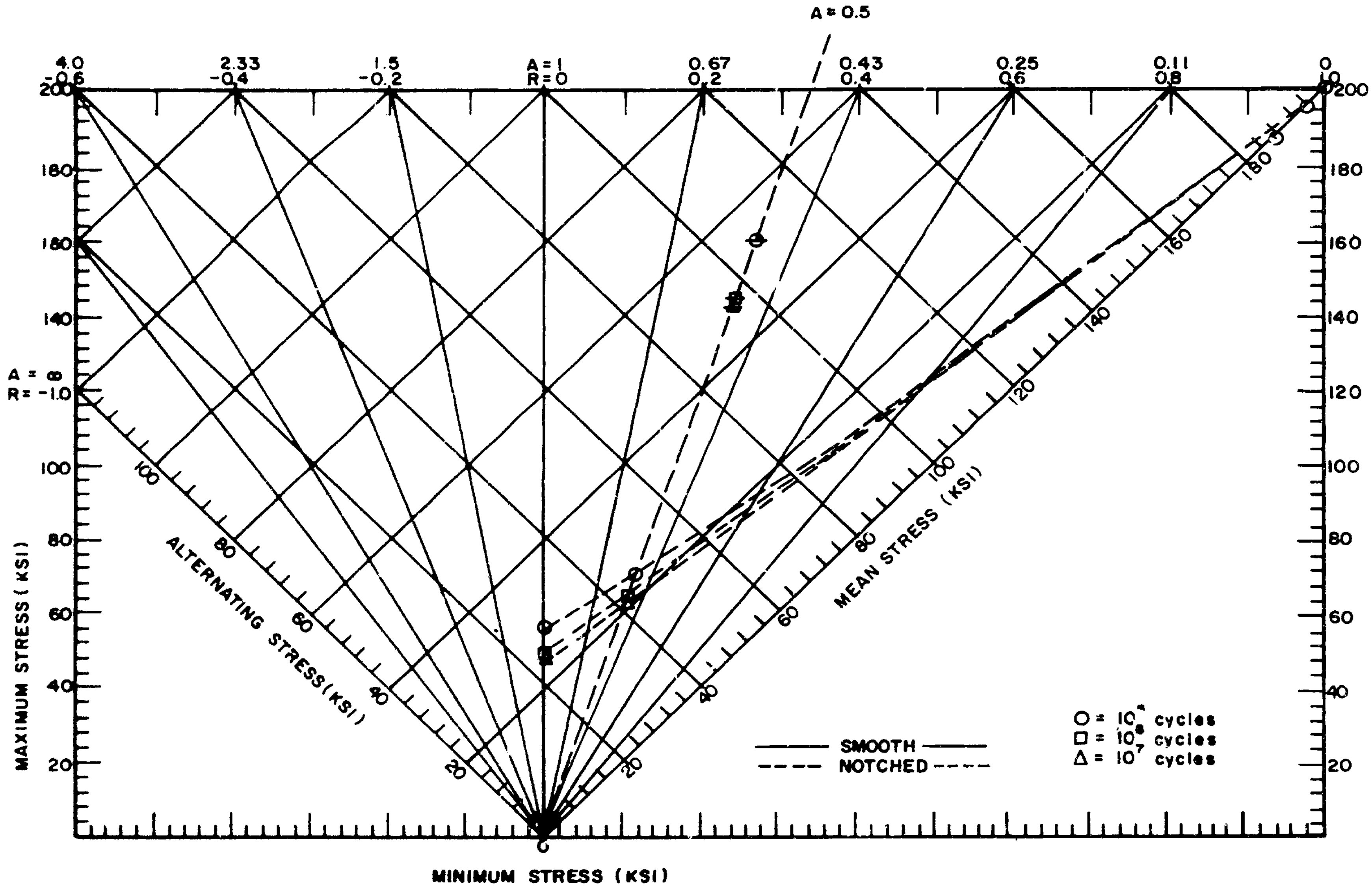

Figure 27. Constant Life Diagram for AM 350 SCT Sheet, Transverse, 500°F

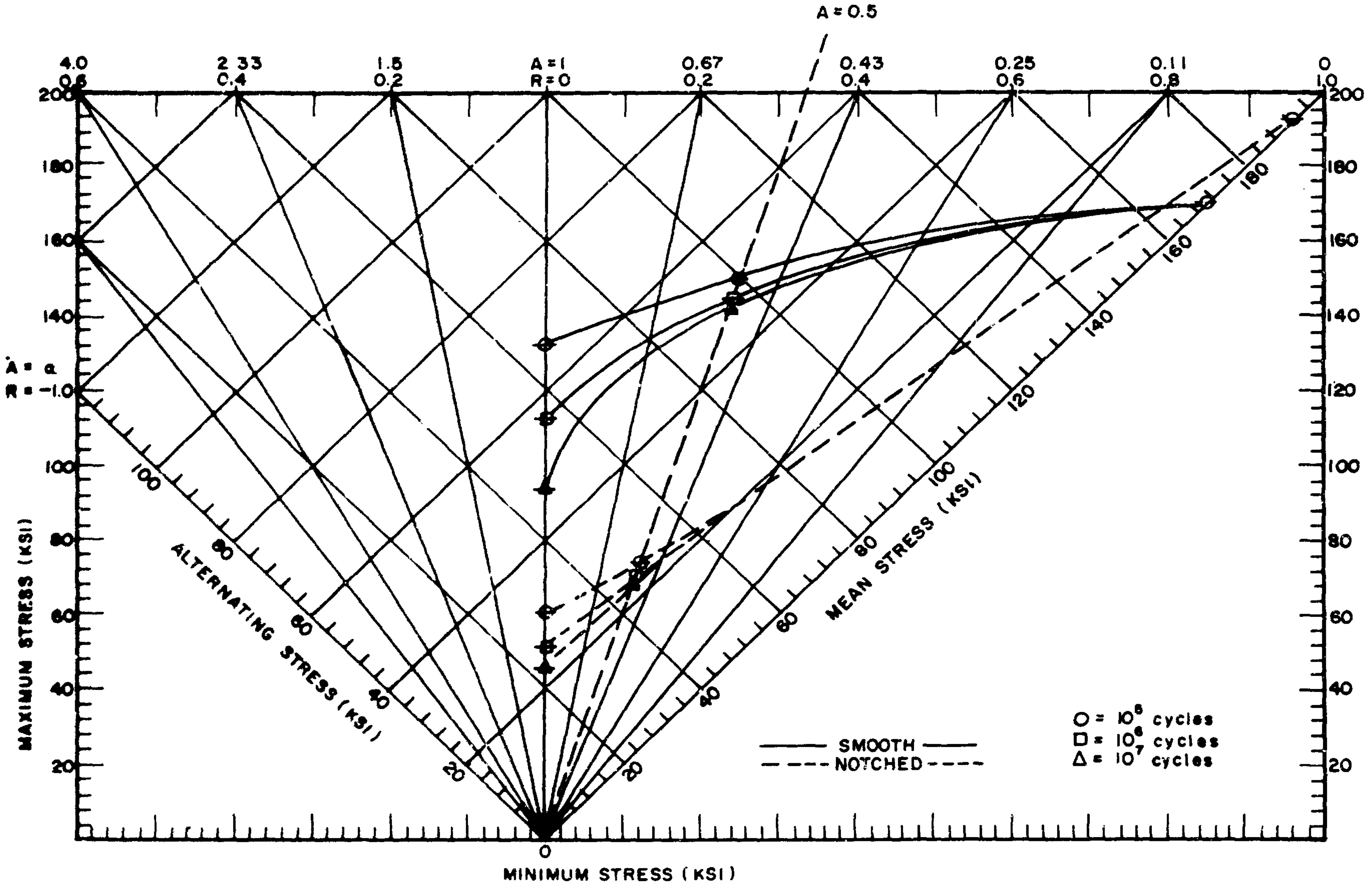

Figure 28. Constant Life Diagram, AM 350 SCT Sheet, Transverse, 800°F

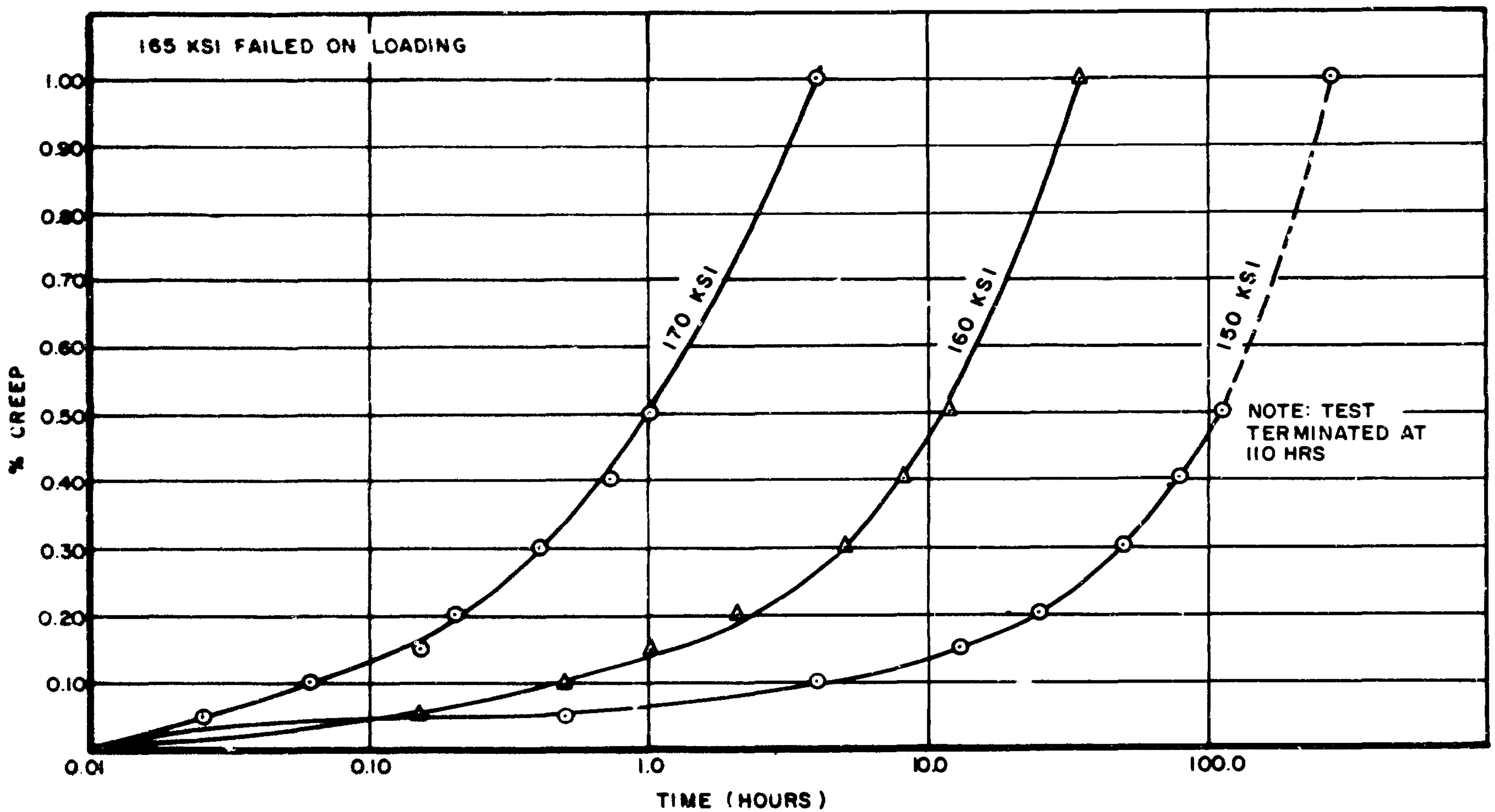

Figure 29. Creep Vs. Time for 17-7 PH at 600°F

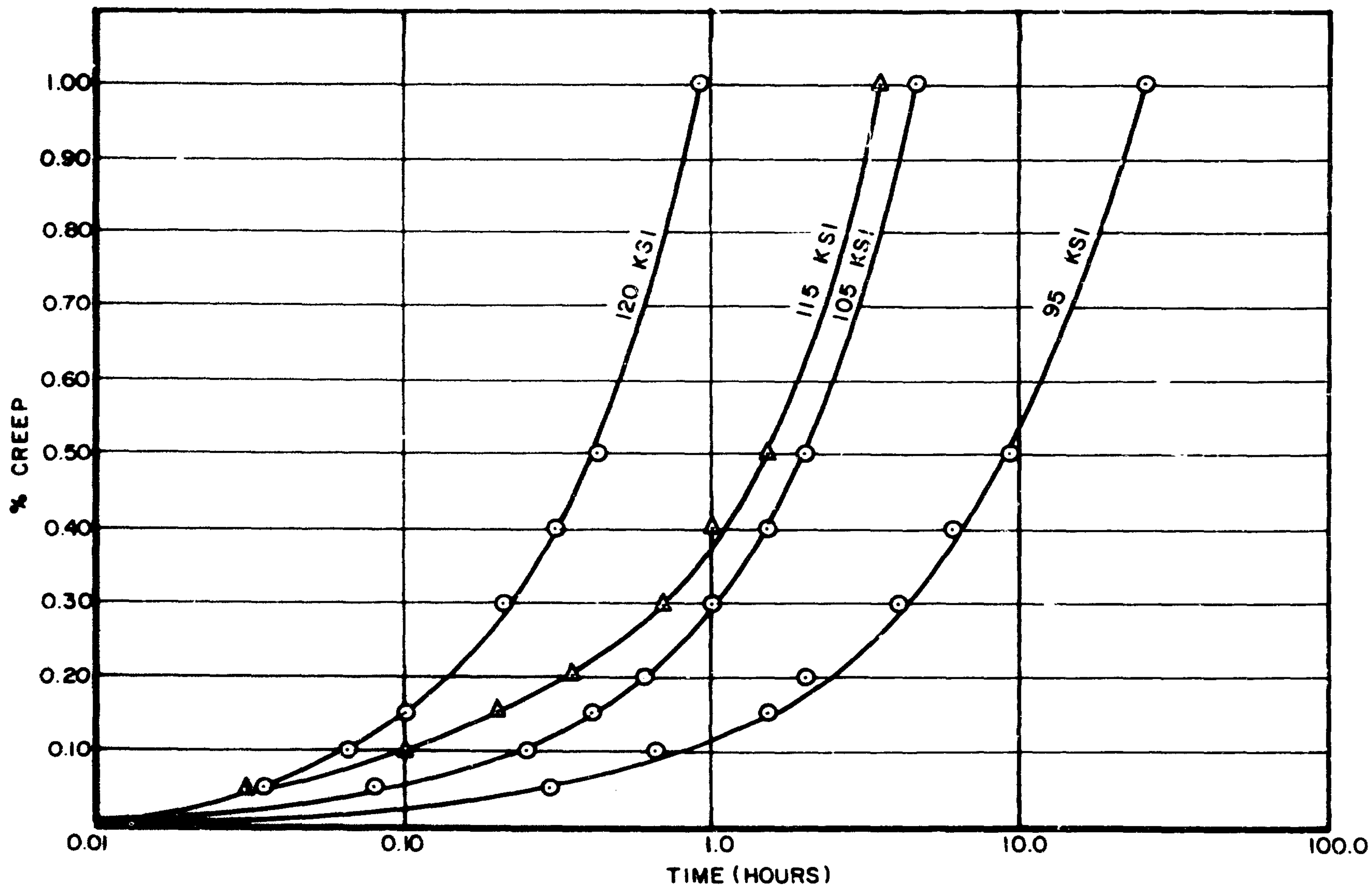

Figure 30. Creep Vs. Time for 17-7 PH at 800°F

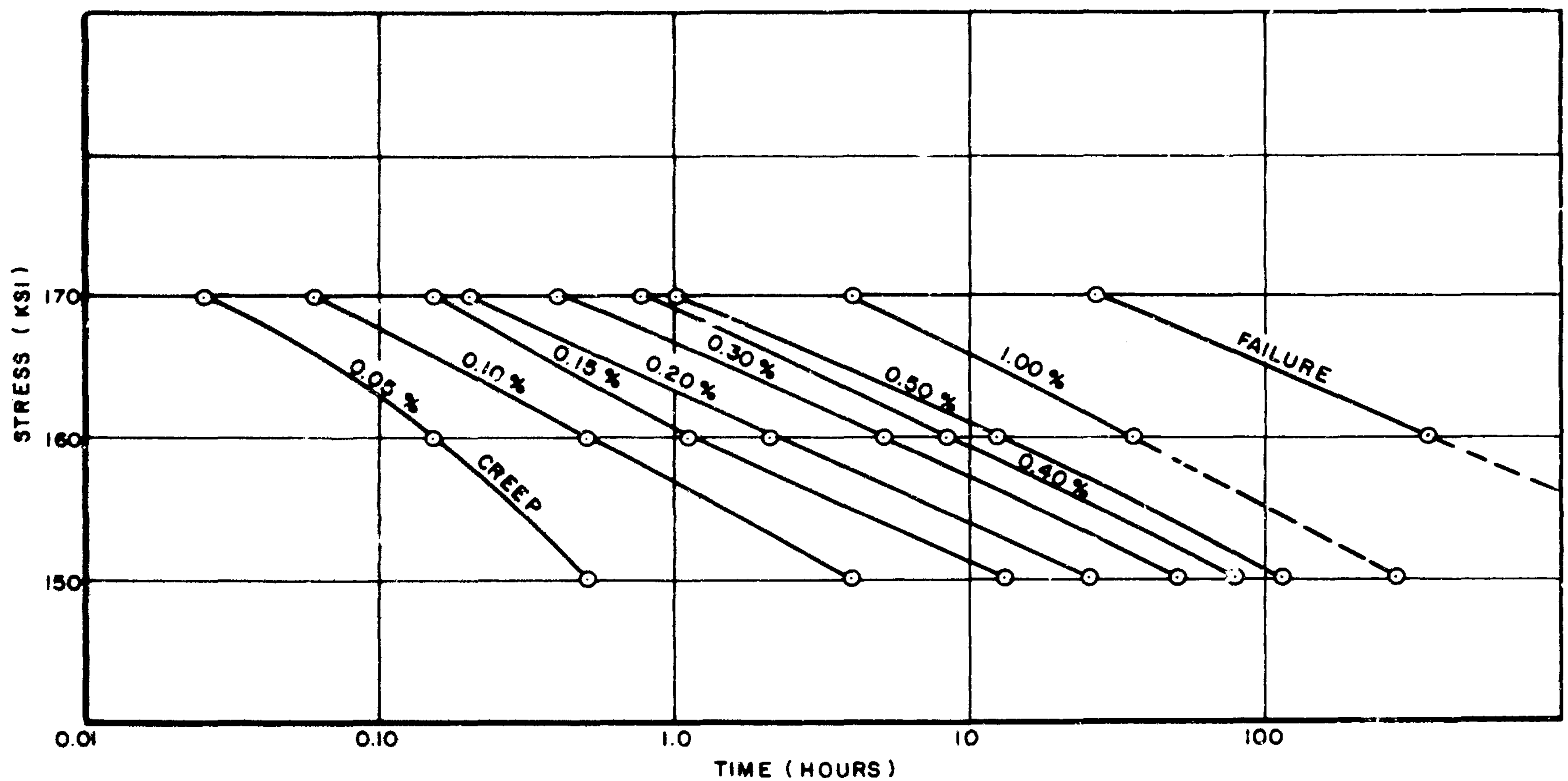

Figure 31. Creep Stress Vs. Time for 17-7 PH at 600°F

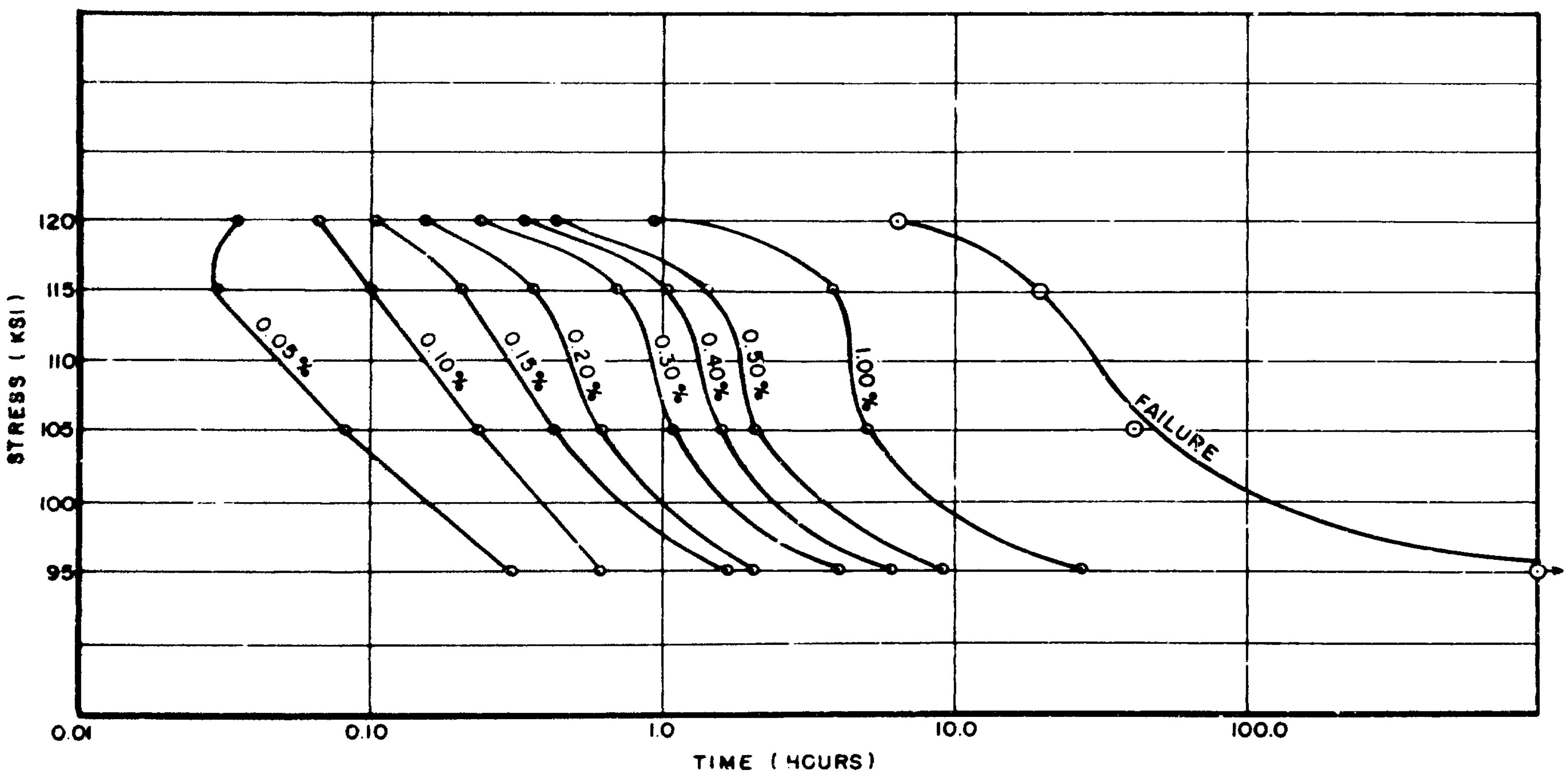

Figure 32. Creep Stress Vs. Time for 17-7 PH at 800°F

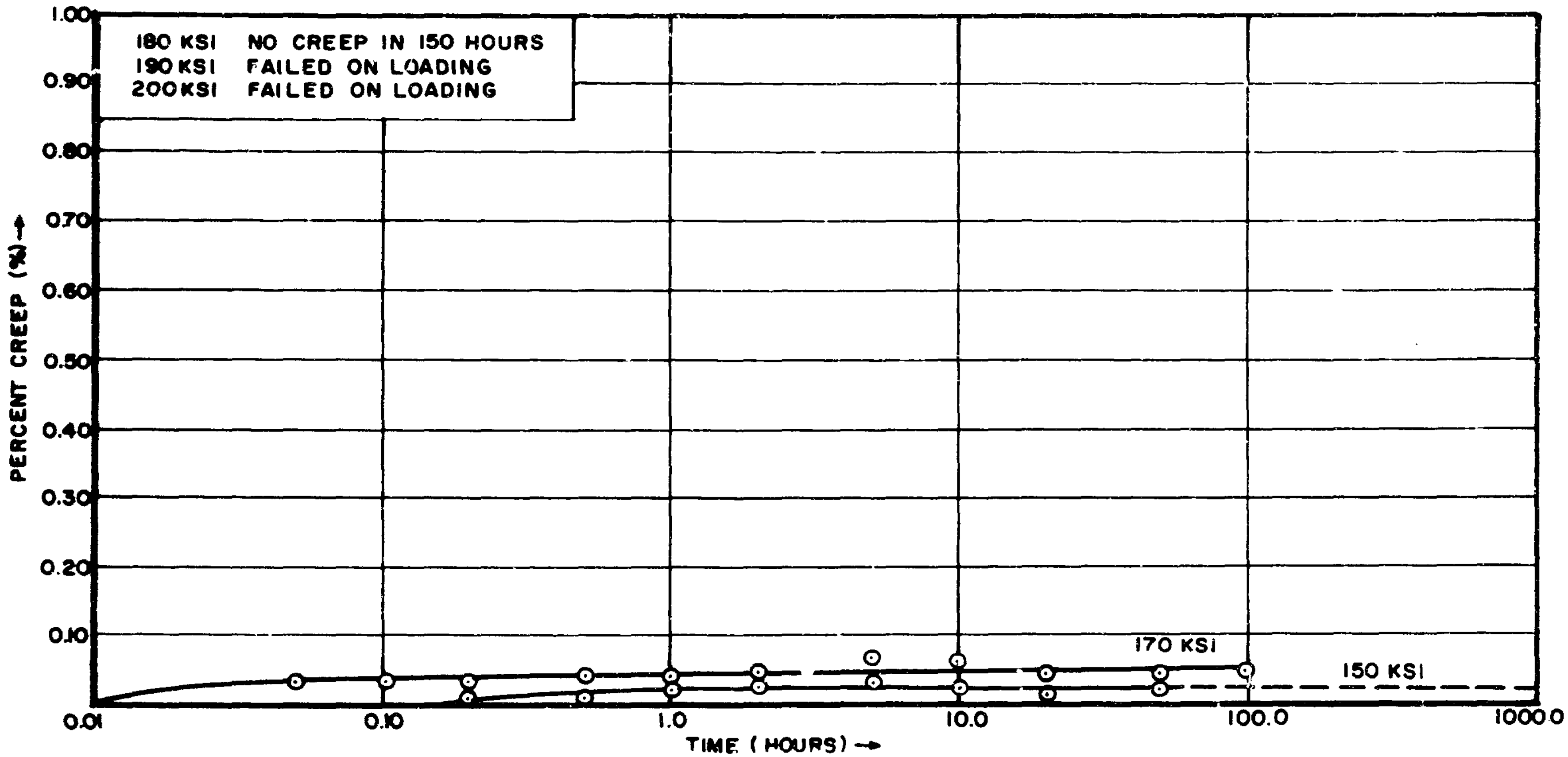

Figure 33. Creep Vs. Time for AM 350 at 500°F

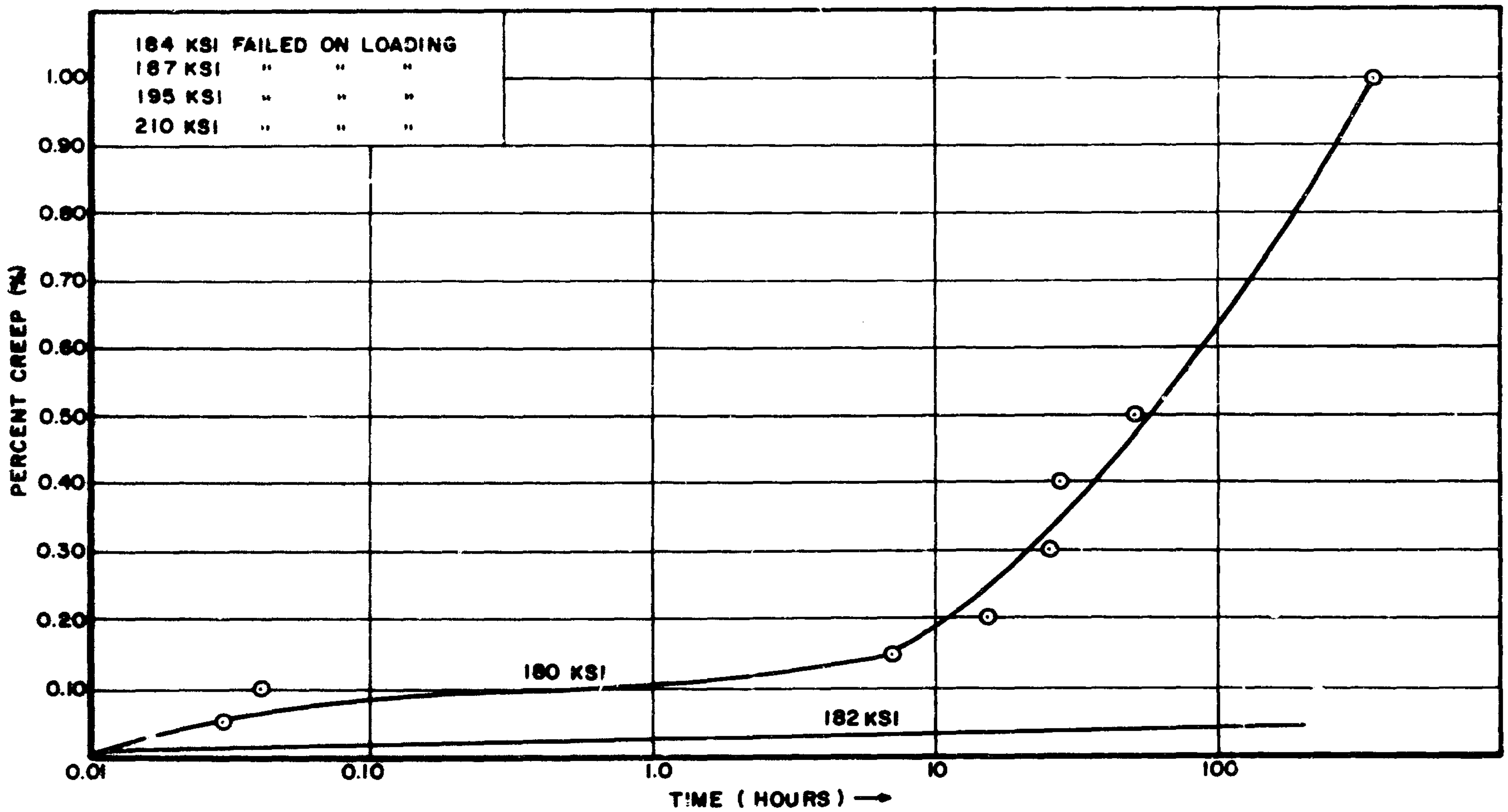

Figure 34. Creep Vs. Time for AM 350 at 800°F

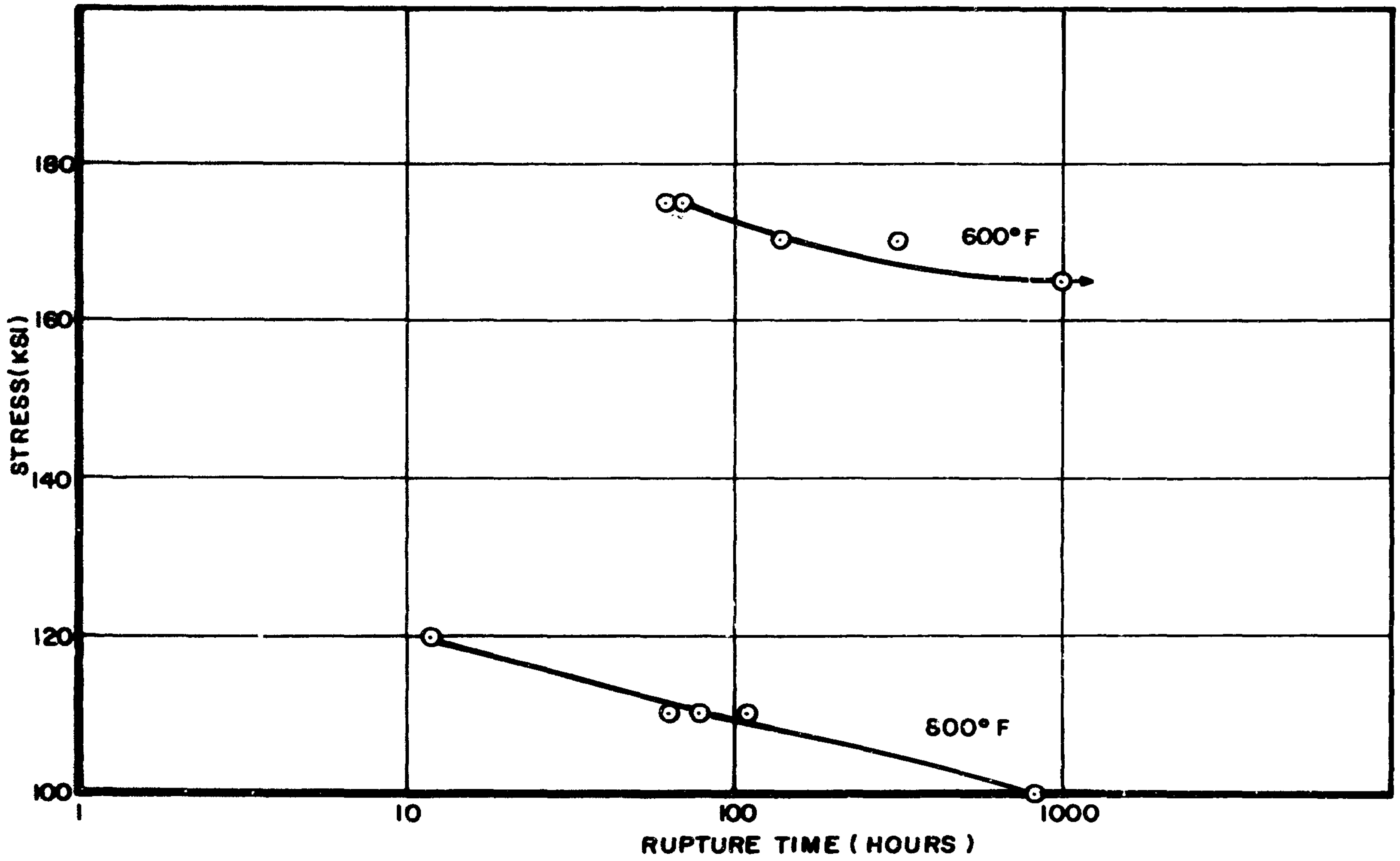

Figure 35. Stress Vs. Rupture Time for Notched, K_t=3.0, 17-7 PH

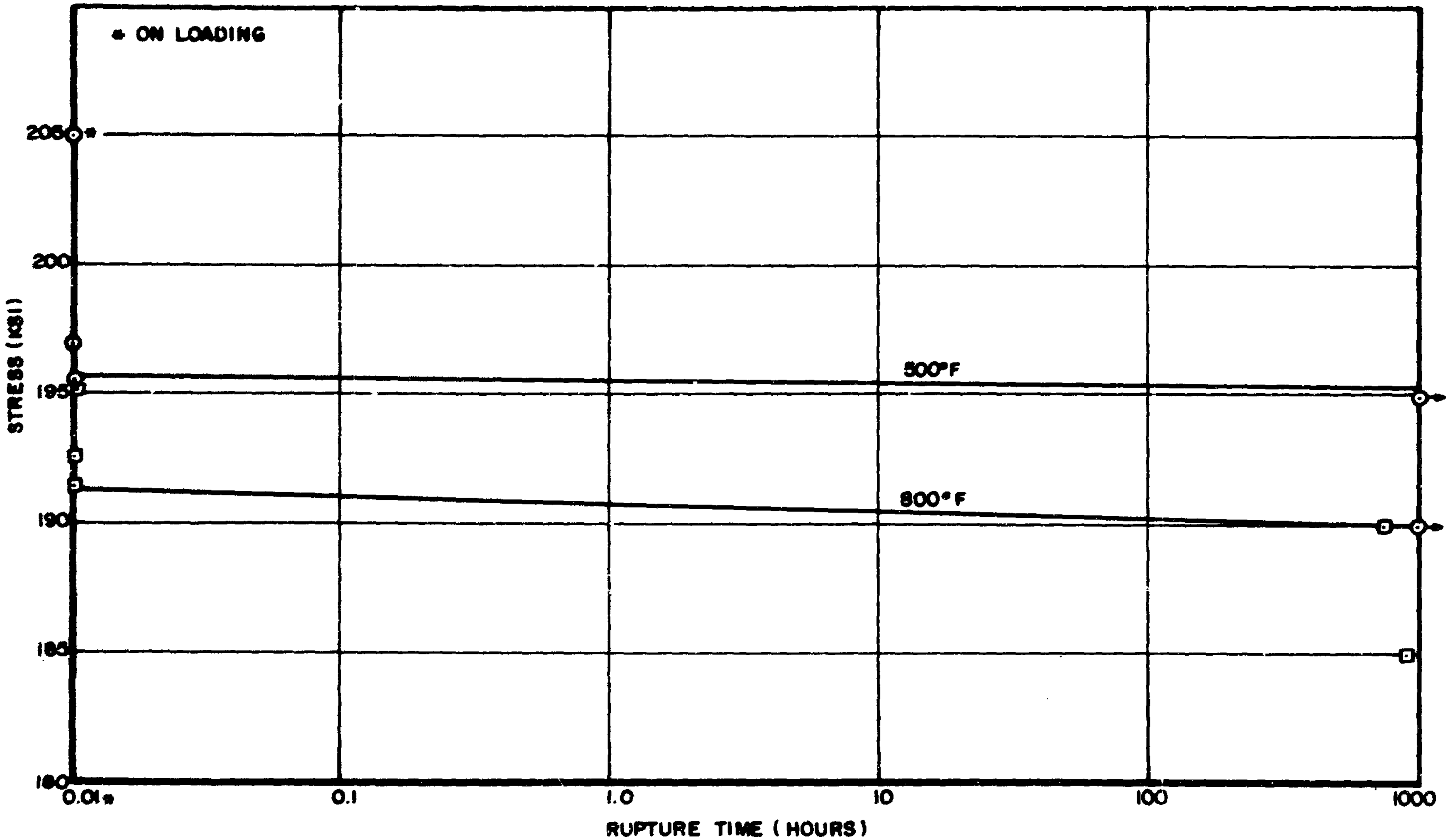

Figure 36. Stress Vs. Rupture Time for Notched, K_t=3.0, AM 350

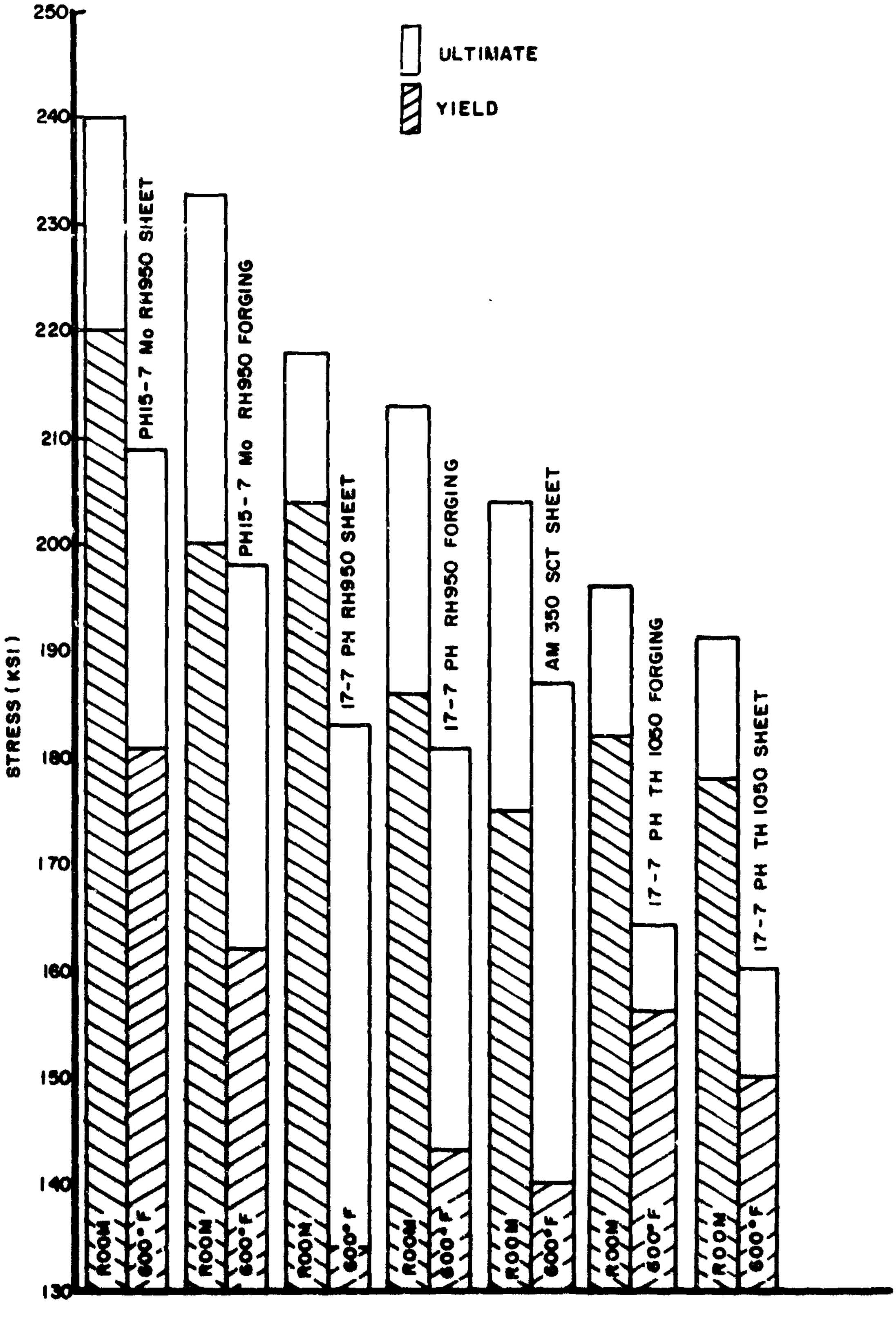

Figure 37. Effect of Temperature on Tensile Properties of 17-7 PH, AM 350, PH 15-7 Mo

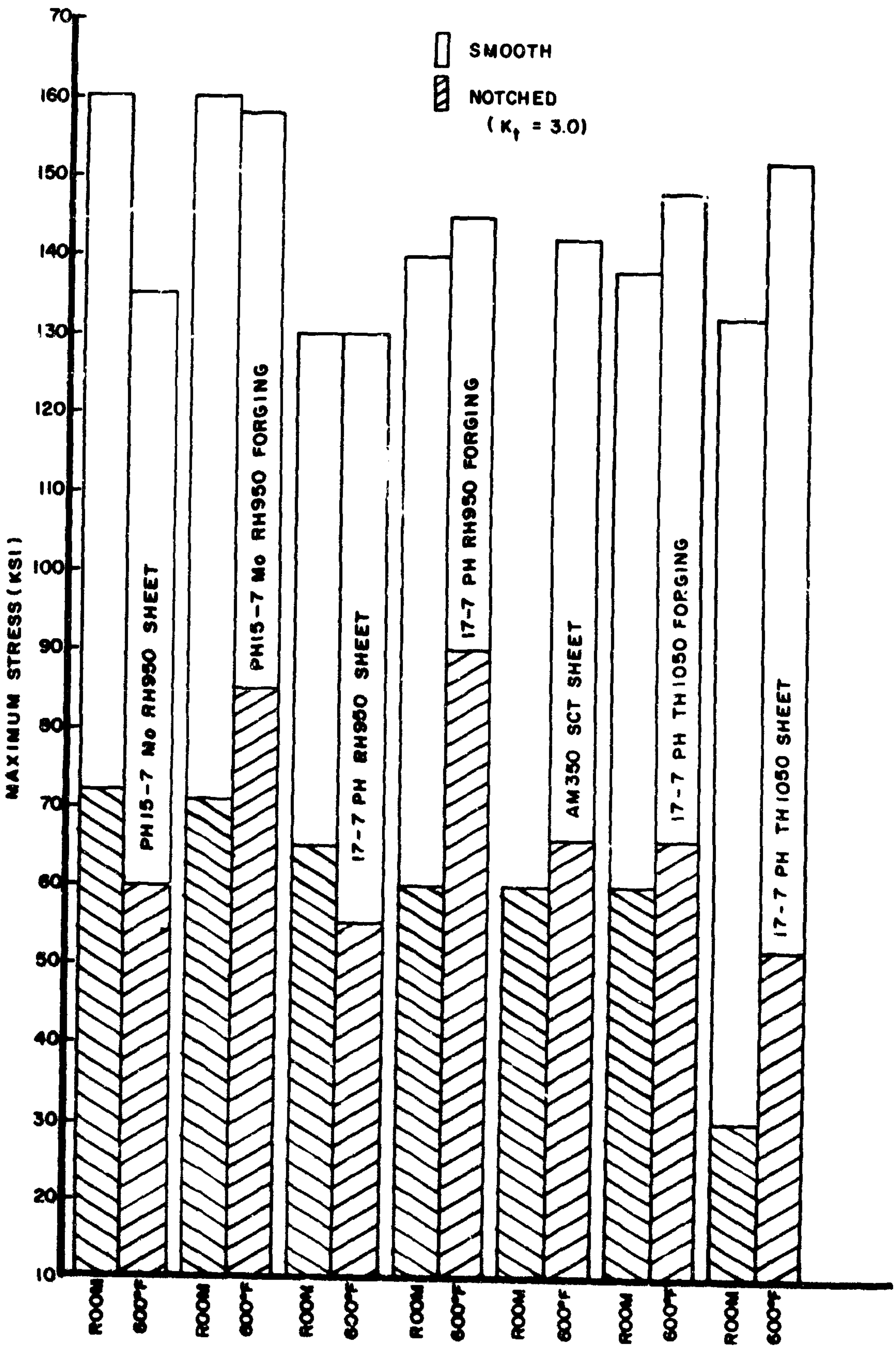

Figure 38. Effect of Temperature on Fatigue Life of 10^7 Cycles at A=0.5 for 17-7 PH, AM 350, PH 15-7 Mo

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

A test program was conducted to develop fatigue data on 17-7 PH TH 1050 and AM 350 SCT stainless steels at room and elevated temperatures. Limited stress-rupture and tensile data were also obtained. This program is part of an overall effort to obtain fatigue data for alloys which are currently in MIL-HDBK-5, but for which fatigue data is currently lacking. All data were generated to be compatible with the MIL-HDBK-5 format and are presented in tabular form as well as stress rupture curves, S-N curves, and constant life diagrams. The results indicated the 17-7 PH TH 1050 had slightly higher fatigue properties at room and elevated temperatures while the AM 350 SCT had slightly higher ultimate tensile strength. Both alloys had lower UTS and fatigue properties than 17-7 PH RH 950 and PH 15-7 MO RH 950 sheet which were tested under a companion program; however, the ductility of these other two alloys was less.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
AM 350 SCT						
17-7 PH TH 1050						
Fatigue						
Creep						